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ORIGINAL ARTICLES.

I.—Further Notes on some Mollusca from South Australia.

By W. H. Hudleston, M.A., F.R.S., F.G.S.

(PLATE IX.)

In the Geological Magazine for 1884[1] some Mesozoic fossils, obtained from near Mount Hamilton and the Peak Station, were noticed by me with figures and descriptions where the specimens were fairly well preserved. Since then additional specimens have been procured from adjoining districts.[2] The general character of the facies is fairly similar to that already noticed in 1884; but on the whole, perhaps, the specimens are scarcely so well preserved. According to the opinion of those who have had most experience, these fossils may be regarded as of "Cretaceo-Jurassic" age, though I am not aware that such undoubted Cretaceous forms as *Ancyloceras*, etc., have been discovered in the beds whence the fossils forming the subject of these notes have been derived.

With the materials before us, mostly in the state of casts, and sometimes only single specimens, a really good specific diagnosis is almost impossible. In those cases where I have ventured to give a name, it must be regarded as mainly for convenience of reference. To constitute species on a sound basis we require better specimens, and more of them, and these it is to be hoped that the collectors will ere long supply.

Ammonites fontinalis, sp.nov. Pl. IX. Fig. 1.

Shell compressed, carinated, involute. Owing to the raising of the umbilical margin the whorls are slightly concave towards the centre; umbilicus deep with steep walls, restricted yet showing portions of each of the inner whorls in succession. In the early whorls and more central portions of the body-whorl the ornaments consist of numerous fine flexuous lines, which have a tendency to pass out-

[1] Dec. III. Vol. I. p. 339 and Plate XI.

[2] The fossils described in this paper form part of a small collection of geological specimens which was exhibited in the South Australian Court of the Colonial Exhibition in 1886, and subsequently presented by Henry Y. Lyell Brown, Esq., F.G.S., Government Geologist for South Australia, to the Trustees of the British Museum (Natural History). They have now been figured and described at the request of Mr. H. Y. Lyell Brown. The collection comprises in addition, some Tertiary Plant-remains, some Tertiary Mollusca, and some Palæozoic Corals and fragments of Trilobites; the latter are from Yorke's Peninsula, and it is hoped that these will shortly be described with the kind assistance of Dr. G. J. Hinde, F.G.S., and other palæontologists.—Edit. Geol. Mag.

wards into reflexed ribs. In the body-whorl (of the only available specimen) these ribs become few in number and very broad, giving a very characteristic appearance to the shell: they do not appear to pass over the ventral (siphonal) area. The suture-lines are only exposed over portions adjoining the siphonal area, but where exposed are exceedingly distinct and well defined. There is a general roundness in the crenulations of the entire suture-line, which, on the whole, may be said to tend towards simplicity. The upper lateral saddle is not deeply cleft, whilst the upper lateral lobe is tridigitate, and almost on a level with the siphonal lobe.

The specimen is well preserved in a hard black argillo-calcareous nodule, which contains *Nucula*, *Cardium*, *Pinna*, *Serpulites*, etc., and the shell, which is highly nacreous, shows good iridescence. It was found at Primrose Springs, north of Lake Eyre, and is stated to be the first Ammonite discovered in South Australia.

This extremely compressed and carinated species, so far as external appearances guide us, has some resemblance to the *Murchisonæ* and *concavus*-group of Ammonites now referred to *Ludwigia* and *Lioceras*. The umbilicus in its step-like character strongly reminds us of the latter. On ascending higher in the geological scale, we are again reminded of such forms as *Am. Henrici*, d'Orb., and *Am. canaliculatus*, Münst. The Cretaceous species, so far as my experience goes, do not offer so many points of resemblance to the South Australian form.

It is worthy of remark that Ammonites have hitherto proved scarce in the Mesozoic deposits of Australia. Tenison Woods, writing in the year 1882 (T.R.S. N.S. Wales, vol. xvi. p. 150), remarks that only seven species had been recorded including the forms recognized by Moore. He described a new form under the name of *Am. olene*, which was said to resemble *Am. biflexuosus*, d'Orb., of the Great Oolite. Mr. R. Etheridge, jun., has figured five species of Ammonites in his "Queensland Palæontology" (unpublished).

ALARIA OR ANCHURA, sp. Plate IX. Fig. 2.

Anchura (Conrad) is a sub-genus of *Alaria* (monodactyl), where the wing presents a securiform bifurcation at the extremity. It seems confined to the Cretaceous, e.g. *Anchura carinata*, Mantell (Fischer, Man. Conch. p. 676).

Approximate length, without the "tail"	35 mm.
Spiral angle	23°.

The number of whorls is from ten to twelve; these are full and rounded in the early stages (the extreme apical whorls are unknown), carinated in the later stages; carina nearly median, and ornamented with short thick tuberculations; a second carina is sometimes displayed at the base of the whorls. Body-whorl angular, salient and bicarinated; the posterior carina very strong and prolonged into a stout digitation, the true termination of which is unknown. In some specimens the carinæ of the body-whorl are tuberculated, in others apparently not so. The sutures are rather open, so that the base of the whorls are partly uncovered. Other indications wanting.

This species occurs in black argillo-calcareous nodules at Primrose Springs. Some of the nodules are full of interior casts, with portions of shell substance adherent, but no casts of the exterior or of the appendages are available at present. Accurate diagnosis and strict comparisons are therefore difficult.

No species of *Alaria* is enumerated in Moore's "Australian Mesozoic Geology"; but Mr. Etheridge, jun., figures *Anchura Wilkinsoni* (Queensland Pal. pl. 31, figs. 4 and 5), which is shorter, possesses a wider spiral angle, and has more slender costæ on the carina of the whorls of the spire than is the case with our species, which I consider to be different. On the other hand, our species presents many points of resemblance to *Anchura carinata*, Mantell, of the Gault. Indeed, if they are not the same species, they are very closely allied; and as I only have access to a cast of the one and to shells of the other, a true comparison is impossible. If we had any evidence of the securiform termination of the wing in the Australian fossil, I should be almost disposed to pronounce in favour of its identification with *Anchura carinata*.

TURBO ? sp. Plate IX. Fig. 3.

The length is about 20 mm.; width rather more, and the spiral angle nearly a right angle. The shell is turbinate, and has three or four whorls, which increase regularly, and do not, as far as may be judged from the cast, present any marked tabulation. Portions of the different shell-layers are preserved, the inner ones exhibiting a considerable amount of nacre. There are no certain indications of external ornament, though the general aspect might suggest a smooth exterior. Traces of a sutural canaliculation are also visible. The aperture is imbedded in matrix, but appears to be circular.

But for the apparent depth of the sutural canaliculation and its larger size, the general aspect of this shell suggests that it belongs to the group of "*Turbo*," which is characterized by *Turbo* (*Nerita*) *lævigatus*, Sow., and which group has been likewise successively referred to *Monodonta*, *Chrysostoma*, and to *Ataphrus*, Gabb. It may be worth noticing that *Turbo lævigatus* was enumerated by Moore from the Greenough district in West Australia.

A single specimen is known from Primrose Springs.

ACTÆON or AVELLANA, sp. Pl. IX. Fig. 4.

Length 6½ mm.; body-whorl about four-fifths of the total length; spire subdepressed, and consisting of about three whorls, increasing under a wide angle. Body-whorl relatively very large, and more ventricose posteriorly than in front. The ornaments consist of regular deep-set punctate furrows, spirally arranged, which leave their impress on the cast of the body-whorl, where they are about twenty-four in number. Aperture broadly ovate, and about two-thirds the length of the shell. Columella much excavated, and showing on the cast the mark of one fold situated anteriorly. Other indications wanting.

There being no shell whatever on the body-whorl, it is difficult to fix the genus with certainty. The general aspect of the cast, and

especially the deep-set punctate furrows, remind us of *Avellana*, whilst the single fold on the columella is in favour of *Actæon*. Cf. *Actæon depressus*, Moore, Q.J.G.S. vol. xxvi. p. 256, pl. x. fig. 20, and R. Etheridge's Queensl. Pal. pl. 29, fig. 9.

A single specimen, probably from Primrose Springs.

PECTEN, sp. Pl. IX. Fig. 5.

Form orbicular and depressed, umbones pointed, auricles moderately unequal. The shell appears to have been nearly smooth, and the ornamentation was confined to concentric lines.

It is somewhat more orbicular than *Pecten socialis*, Moore (vol. *cit.* p. 248, pl. xi. fig. 9). There is a certain general resemblance to *Pecten orbicularis*, Sow., and in a less degree to *Pecten demissus*, Phil.

A single specimen from Hamilton Station near Lake Eyre.

PSEUDAVICULA ANOMALA, Moore, 1870.

1870. *Lucina anomala*, Moore, Q.J.G.S., vol. xxvi. p. 251, pl. xiv. f. 4.
1884. *Avicula orbicularis*, Hudl., GEOL. MAG. Dec. III. Vol. I. p. 341, Pl. VI. Fig. 10.
1890. *Pseudavicula anomala*, Moore, Queensland Palæontology, pl. xxiv. fig. 13.

Mr. Etheridge, jun., is probably right in assuming that *Avicula orbicularis* is a synonym of *Lucina anomala*, though Mr. Moore was very wide of the mark in referring an aviculoid shell to the genus *Lucina*. As the diagnosis of *Pseudavicula* is not known to me, I am not able to point out in what respect it is held to differ from *Avicula*.

If Mr. Etheridge is correct in identifying *Lucina anomala* and *Avicula orbicularis*, the species occurs both in Queensland and in the Lake Eyre District (South Australia).

PINNA AUSTRALIS, sp.nov. Plate IX. Fig. 6.

Estimated length, 160 mm.; full width in front 45 mm. Shell elongate, narrow, deep; section in front sub-rhomboidal. Dorsal margin nearly straight, ventral margin but little sloped, and slightly incurved. Each valve is unequally divided by a longitudinal ridge, in which is impressed a sulcus forming a line of weakness resulting in actual fracture towards the front. Shell substance rather thick. The ornaments consist of numerous straight longitudinal ribs along the narrow dorsal area, whilst on the wider ventral area the ribs are broader and more curvilinear.

The materials for a full diagnosis are of necessity wanting where so little of the shell has been preserved; but there seems some justification for constituting a new species in this case. The form is less wedge-shaped than *Pinna cuneata* of the Oolites, and in some respects more nearly approaches *Pinna tetragona*, Sow. (M.C. t. 313, f. 1), where the valves are even more carinated than in this one, and where the section consequently is more thoroughly tetragonal. Our species therefore may be regarded as intermediate between the cuneate and tetragonal forms of *Pinna*.

No species of *Pinna* has hitherto been described, so far as I am aware, from Australia, but there is a fragment of a large *Pinna* figured in Queensland Palæontology, pl. 20, figs. 16 and 17, and

reference made to *P. laticostata*, Stol., Cret. Rocks India, Pelecypoda, Pal. Indica, vol. iii. 1871, p. 385, pl. xxv. fig. 2–3, and xxvi. fig. 4. The specimen figured is from a sandy bed at Primrose Springs.

MYTILUS, sp. Plate IX. Fig. 9.

This is a true *Mytilus*, the umbones being terminal. It is distinguished by the marked convexity of the upper or hinge border and a corresponding incurvation of the lower margin. There is no shell left; but, to judge from indications on the cast, broad concentric lines constituted the principal ornamentation.

This cast is perhaps somewhat too compressed for *Mytilus rugocostatus*, Moore, and both margins are rather arcuate.

There are no indications as to locality with this specimen, which probably comes from the Lake Eyre district.

MYTILUS LINGULOIDES, Hudleston, 1884.

1884. *Modiola linguloides*, Hudl., GEOL. MAG. Dec. III. Vol. I. p. 341, Pl. XI. Fig. 6.

I take this opportunity of pointing out that *Mod. linguloides* is really a *Mytilus*. Large specimens of this species occur 45 miles South-West of Coattonoona Station in the Lake Eyre district. It may possibly be the same as *Mytilus inflatus*, Moore, (*op. et* vol. *cit.* p. 252, pl. xiii. fig. 4), but would seem to run larger and to be somewhat less inflated than Moore's species.

MODIOLA SUBSOLENOIDES, sp.nov. Pl. IX. Fig. 8.

Length from umbones to lower border about 55 mm. Umbones rather blunt; umbonal ridge much thrown back towards the dorsal or hinge-border. Shell subelongate and gibbous; anterior area straight and marked by rugose concentric lines, which are much less strongly developed in the dorsal or hinge area, which slopes from the umbo, and curves round to meet the posterior extremity. This latter is considerably dilated, being $2\frac{1}{2}$ times the width of the anterior extremity.

This species possesses considerable resemblance to *Myoconcha*, but the shape of the umbones and the subnacreous character of the inner layers of shell are against this supposition. In figure it possesses a general resemblance to "*Mytilus*" *solenoides*, Morris and Lycett (Great Oolite Moll. Biv. p. 38, pl. iv. fig. 1).

No locality is recorded, but it probably comes from the neighbourhood of Lake Eyre.

THRACIA PRIMULA, sp.nov. Pl. IX. Fig. 7.

Length to width about as 5 : 3·5. Shell extremely thin, subovate, and but slightly inequivalve, extremely compressed. Umbones a little posterior, and giving rise to a slight curvilinear ridge in the posterior area. Anterior side suborbicular, posterior extremity squarely truncate. Breadth of anterior to posterior side as 3 : 2. The ligament is well developed, and occupies one-third of the length of the posterior dorsal margin. Rather broad concentric lines of growth ornament the shell.

This species resembles *Thracia Wilsoni*, Moore (vol. *cit.* p. 254, pl. xiv. fig. 8, figured as *Corimya Wilsoni*, Moore, in Quensl. Pal. pl. 28, figs. 10, 11). It is chiefly distinguished from that shell by the difference between the anterior and posterior breadth, and possibly also by its smaller habit of growth.

Locality.—Primrose Springs, north of Lake Eyre.

EXPLANATION OF PLATE IX.

South Australian Fossils.

Fig. 1. *Ammonites fontinalis*, sp.n. Primrose Springs, Lake Eyre.
,, 2. *Alaria* (? *Anchura*) sp. cf. *Anchura carinata*, Mantell. Primrose Springs.
,, 3. ? *Turbo*, sp., cf. *Turbo lævigatus*, Sow. Primrose Springs.
,, 4. *Actæon* or *Avellana*, species. ? Primrose Springs.
,, 5. *Pecten*, species. Mt. Hamilton Station, near Lake Eyre.
,, 6. *Pinna australis*, sp.n. Sandy bed at Primrose Springs.
,, 7. *Thracia primula*, sp.n. (right valve). Primrose Springs.
,, 8. *Modiola subsolenoides*, sp.n. No locality.
,, 9. *Mytilus*, sp. No locality.

II.—The Extension of the Mellard Reade and C. Davison Theory of Secular Straining of the Earth to the Explanation of the Deep Phenomena of Volcanic Action.

By H. J. Johnston-Lavis, M.D., B.-ès-Sc., F.G.S., etc.

FOR many years my thoughts have been occupied with the phenomena of eruption at or near the surface, and although a detailed study of the Vesuvian volcano and its products gave me the key to the mechanism of eruption and injection of igneous matter near the surface, I was always at a loss to understand, on the older theories, how lava could ever start upwards in fissures.

It has been said that volcanic action was the cardinal point upon which hung the hypotheses and theories which have been or may be offered in explanation of those geodynamical problems which are the very basis of geology. Six years since, that group of phenomena which constitute eruptive activity at the surface of our planet were recognized as due to the presence of elastic vapours contained within the fused rock; but no ideas had been offered, and still less any law formulated, of the introduction into and separation of these volatile constituents from the igneous magma which is the cause of all the modifications of eruptive actions as we see it. In my paper on the Geology of Monte Somma and Vesuvius, the conclusions I had been led to by the study of that volcano, as illustrating surface eruptive phenomena in general, were given and the paper was terminated by 50 propositions which appeared to me as being supported by those studies.[1] After my further investigations at other volcanoes, finding an overpowering abundance of confirmatory evidence, those conclusions were united in another paper of mine read before the Geological Society on April 29th, 1885, entitled, "The Physical Conditions involved in the Injection, Extrusion, and Cooling of Igneous Matter," and which enunciate the physical laws

[1] These conclusions and propositions, contrary to my wishes, were not allowed to appear in the memoir at the time it was published, Q.J.G.S. Feb. 1884.

governing eruptive action." This paper, for some unknown reason, was suppressed; but in 1886 it was at last published in the "Proceedings of the Royal Dublin Society." That memoir, though so much delayed, has precedence of the interesting studies of Lagorio, and recently of Iddings.

Although these preliminary statements might appear as outside the present subject, they are not so; for it is necessary to separate absolutely the *superficial* from the *deep phenomena* of the eruption of igneous matter, and reference to those papers should be made, so that it may be seen that there such distinction has been made, and a full explanation of the superficial ones given. What was assumed as necessary to that explanation was, if required, an unlimited amount of igneous matter coming from below. It is just this assumption that is now to be discussed in the light of the new theory of secular straining of the earth which I contend will give the first clear and satisfactory explanation of *deep volcanic action.*

In the old theory of the earth-crust crumpling over a contracting and cooling nucleus, fluid or partially so, it always appeared to me to be inexplicable how fluid matter could be squeezed out, or why all the fluid on the surface of the earth did not rush down to fill up any vacancy that the contracting interior tended to produce.

This perhaps is expressing the facts in simple commonplace terms, but is sufficient to illustrate the incompatibility of this hypothesis with the fact of some of the liquid interior of the earth rising through fissures towards the surface.

The hypothesis that tangential thrust did not exist, but that the earth-crust was shrinking and compressing an entire or partial fluid nucleus, would have satisfied the vulcanologist, but is absurdly contrary to the incontrovertible evidence of tangential compression, as seen in the plications and overthrusts existing upon the whole surface of the globe.

The Mellard Reade and Davison theory is reasonable in itself, and satisfies alike the student of mountain building and the vulcanologist. Prof. O. Fisher's criticisms at first sight seem rather serious to the theory itself; but when we consider the most flimsy nature of the data of the age of our earth, the temperature of solidification and the rate of cooling, we may safely say that the mathematician has yet to have his day. Besides this, even the nature, and still more the conductivity of all rocks beyond two miles from the surface is unknown.

The new theory tells us that the shells from the uncooled nucleus out to the zone of maximum cooling lose more and more heat; and their tangential strain increases—a condition in fact identical with the guns built up of steel rings, shrunk on, one above another. The tendency of all the shells beneath the no-strain zone is not only to crumple all above it, but to compress the uncooling nucleus; but when that compression has reached its maximum limit, equilibrium can only be restored either by fluxion stretching or shearing (how about foliation) or fracture. This fracturing would tend to be fusiform in section (I am open to correction) with the maximum

separation of the sides at the zone of maximum cooling, with one extremity reaching on one side to the uncooling nucleus, and on the other to the zone of no-strain. But the compression exerted on the nucleus by the shells beneath the no-strain zone would cause any part of it sufficiently fluid to rise and inject this fissure. In consequence of this, we should have a mass of igneous matter that would have become more fluid by diminished pressure connected by a narrow neck below at the lowermost shell of cooling, but its maximum bulk at the zone of maximum cooling, whilst its most excentric or uppermost prolongation would reach the *zone of no-strain.*

Now the shrinking shells beneath the *no-strain layer* will tend to draw to and within themselves the water squeezed out of the crushed shells above the *no-strain layer*, and this would be particularly marked at *the zone of no-strain*, and just below it where we have seen the outermost limits of the fissure injected with igneous matter reaches. In other words, we have highly heated magma in contact with the aquiferous strata, the conditions required in the memoirs referred to to explain the whole of the remaining or *superficial* eruptive phenomena. The compression of the shells above the *no-strain* zone will tend to prevent the progress of the magma in the upper part of the fissure towards the surface as it increases in tension by the gradual absorption of water from the surrounding rocks. This resistance is at first slight, because the lowermost shells near the *no-strain* zone are interested where the compression or crushing is at its minimum, as, however, the magma gradually bursts its way by prolonging the fissure further and further towards the surface, the increased resistance is counterbalanced by the increased supply of water and consequent solution thereof, so that the tension of the magma may rise more rapidly, and also by the crushing and compression being resolved into crumpling and shearing at the free surface of the earth.

I do not for one moment suppose that every fissure that forms becomes eventually a chain of volcanoes for conduction, convection, etc., balanced against initial temperature of magma, and many other circumstances may be such as to bring about solidification.

This constant compression of the terrestrial nucleus would have the effect on the one hand to tend to its solidification. Even were the whole of the earth's interior solid, the moment the tearing asunder took place in the lowermost shells underlying cooling and contraction, the relief of pressure on the nucleus in the neighbourhood of the newly-formed fissure would no doubt be sufficient to allow the solid to pass into a fluid state. Individually, I cannot persuade myself that even if the uncooling nucleus of the earth is not fluid, or its outer surface fluid, yet there must be large intratelluric reservoirs of fluid rock. One of the principal reasons of this is that over large areas we find some dominant chemical character of the essential volcanic products, the only sure guide to a common origin of igneous rocks. No more striking example could be cited than Italy, where potash is practically always the dominant alkali in all

the volcanoes of that country, the presence of which is difficult of explanation in any other way than as an original constituent of the primitive magma. Silica, lime, magnesia, iron, alumina, and even soda, might be explained when abundant, as being taken up from the rocks traversed, but this is not the case with potash.

Lastly, this theory will explain that constant, continuous, though small supply of magma that is necessary for the never-ending ejections of Stromboli, or the dribbling of lava that goes on almost uninterruptedly at Vesuvius.

At any rate, it seems that we have in this theory a more satisfactory explanation of terrestrial phenomena acceptable alike to the tectonic geologist as to the vulcanologist.

III.—Notice of New and little known Fish Remains from the Blackband Ironstone of Borough Lee, near Edinburgh.

No. VI.

By Dr. R. H. Traquair, F.R.S., F.G.S.

Ctenodus interruptus, Barkas.

Ctenodus interruptus, T. P. Barkas, Scientific Opinion, vol. ii. 1869.
,, ,, A. S. Woodward, Ann. Rep. Yorks. Phil. Soc. 1889, pl. i. f. 2.

THIS interesting species has hitherto been known only by the single type-specimen, a mandibular tooth, contained in the York Museum, originally described by Mr. T. P. Barkas, and recently very correctly redescribed as well as figured by Mr. A. Smith Woodward. It so happens that some years ago a considerable number of these teeth, both mandibular and palatal, occurred in the Borough Lee ironstone: my own collection contains no less than forty specimens, and there are many others in the Museum of Science and Art, so that I may now add considerably to the knowledge of the species.

Mr. Woodward finishes his description as follows:—"As remarked by Mr. Barkas, the tooth thus described is distinguished from the teeth of the most nearly allied species, *C. cristatus*, by the comparative smoothness of the inner moiety of each ridge, and by the distinct separation of the much compressed denticles." But the York specimen is only one of a very variable series of forms, and, of the characters here given, only one is constant, namely, the compression of the denticles in a direction at right angles to that of the ridges. Sometimes this character is only very distinctly marked at the outer margin of the tooth-plate, or on its posterior two-thirds, but it is nevertheless seen with absolute constancy in all specimens in which the denticulation is not entirely removed by abrasion, as is sometimes the case. The "comparative smoothness of the inner moiety of each ridge," though a frequent, cannot be said to be a constant character, as I have specimens both mandibular and palatal in which the ridges are denticulated up to their origins, while on the other hand the ridges may be almost entirely smooth until close to the outer margin of the tooth. It is clear that this condition, instead of being specific, is entirely dependent on the amount of abrasion to which the tooth has been subjected in performing its

masticatory functions; for as a general rule it is less marked in the smaller than in the larger specimens. And also, as a rule, the palatal teeth seem to have suffered more from this tear and wear than the mandibular ones.

Ctenodus interruptus is still more variable in its form than *Ct. cristatus*; in fact hardly two of the numerous specimens which I have seen can be said to be alike. Some are proportionally longer, others broader in their shape; in some the ridges are more transverse, in others more radiating in their direction, and, as above noticed, the extent to which the ridges are tuberculated displays a wide range of variation. The number of ridges on the type-specimen is fourteen, two being intercalated at the margin; but the usual number upon the mandibular tooth is eleven or twelve, though in one case they are reduced to nine. Bifurcation or intercalation of the ridges is also common in mandibular teeth, and indeed at the posterior extremity of the tooth-plate they often appear altogether broken up into groups of tubercles. In the palatal teeth the ridges are usually more regular, and their number varies from twelve to fifteen. A portion of the hinder part of the cranial roof shows that the median occipital plate was pointed in front, as in *Ctenodus cristatus*.

Although it is not difficult to tell a specimen of *C. interruptus* from one of *C. cristatus* by the general appearance, and indeed at the first glance, it is nevertheless by no means easy to put into words a set of characters which shall absolutely separate the two from each other. The only absolutely constant feature of *C. interruptus* is the compression of the denticles in a direction at right angles to the ridges; but I have before me now a mandibular tooth of *C. cristatus* from Newsham which does also to a *slight* extent exhibit that character as well as the comparative smoothness of the inner moiety of the ridges. And it must also be pointed out that the "type" specimen is not very *typical* in its shape, as the majority of specimens have a considerably greater resemblance to *C. cristatus*. I have therefore been for years in a state of doubt as to whether *C. interruptus* should be retained as distinct, but the absolute constancy of the peculiar compression of the outermost denticles in all those Lower Carboniferous specimens certainly seems to be a justification for calling them by a different name from that of their close relatives in the Coal-measures.

The type-specimen of *C. interruptus* is said to be from Gilmerton; it is contained at all events in a piece of undoubted Scotch Lower Carboniferous ironstone. I have, however, never myself met with a specimen in the Gilmerton ironstone, though that of Borough Lee and Loamhead has yielded so large a number. It occurs also in the Carboniferous Limestone series at Kinghorn, Fifeshire; in the Calciferous Sandstone series at Pittenweem in the same county; and at West Calder, Midlothian. In the west of Scotland it has occurred in the ironstone of Barkip, Dalry (Carboniferous Limestone series), specimens from that locality existing in the collections of Mr. R. Craig Beith and Mr. John Smith.

Hemictenodus, Jaekel.

In a recent paper[1] Dr. Otto Jaekel has proposed to institute the genus *Hemictenodus* for *C. obliquus* of Atthey and a species from the German Trias. This new genus he characterizes by the small number of ridges on the teeth, as compared with those of such a form as *Ctenodus cristatus*, and considers it to be intermediate between *Ctenodus* and *Ceratodus*, in fact an illustration of the evolution of the one genus from the other. Into the latter aspect of the question I cannot follow Dr. Jaekel, as I consider the gap between *Ctenodus* and *Ceratodus*, in spite of the opinions of Prof. Anton Fritsch, to be far too wide to be bridged over simply by a comparison of shapes of teeth. The consideration as to whether *Ctenodus obliquus* may not be adopted as the type of a new genus is, however, quite another matter.

In briefly describing portions of cranial shields of *Ctenodus* from the Northumbrian Coal-field, Messrs. Hancock and Atthey[2] drew attention to the fact that in the species *obliquus* the median occipital plate was concave in front, while in *tuberculatus* (= *cristatus*) it "projects, and has a wedge-shaped process in the centre." And an undoubted skull of *Ct. cristatus*, belonging to Mr. Ward, F.G.S., of Longton, and figured in outline by Prof. A. Fritsch, shows that in point of fact the median occipital plate was pointed in front, and related to the neighbouring plates as in *Dipterus*, the anterior pair of the three pairs of plates, which border it on each side meeting in the middle line in front of it. A different arrangement is, however, shown in the skulls figured by Mr. T. P. Barkas[3] and Prof. Miall,[4] in which the median occipital has the anterior concavity as in the specimens attributed to *obliquus* by Hancock and Atthey, and to this concavity articulates a second median plate of considerable size, which entirely separates the anterior pair of lateral bones from each other. That the skulls showing this arrangement belong to a group typified by *C. obliquus* there can be no doubt, any more than that the other pattern is characteristic of *cristatus* and such allied forms as *interruptus*. The question comes to be,—Is this distinction *generic*? I think so myself, though, as in other cases, it may not seem so to other minds differently constituted.

Hemictenodus quinquecostatus, Traquair.

Ctenodus obliquus, var. *quinquecostatus*, Traquair, Geol. Mag. Dec. II. Vol. X. December, 1883.

Owing to the general resemblance which the teeth of this species bear to those of *C. obliquus* I originally described it as only a variety of that form, but the constancy of the smaller number of ridges induces me to elevate it to the rank of a species. In *H. obliquus* the usual number is six to eight; here the regular number is five, with only rarely a rudimentary sixth one.

The top of the skull shows the same general arrangement of

[1] Sitzungsb. der Gesellsch. naturforschender Freunde in Berlin, 1890.
[2] Ann. and Mag. Nat. Hist. (4) vii. 1871, p. 193.
[3] Manual of Coal-measure Palæontology. [4] On some bones of *Ctenodus*.

plates as in *H. obliquus*, though the median occipital plate seems proportionally rather larger and broader, and the second median plate in front of it rather smaller. Many specimens have occurred showing the body of the fish, but unfortunately usually in a rather jumbled condition; a comparison of those specimens, however, pretty plainly shows that the general shape was like that of *Ceratodus*, as I long ago pointed out was the case in *Ctenodus* (= *Campylopleuron*[1]), namely, that the tail was protocercal, and a long continuous dorso-caudal fin present.

Uronemus splendens, Traquair.

Ganopristodus splendens, Traquair, Geol. Mag. Dec. II. Vol. VIII. Jan. 1881, p. 37; and Vol. IX. Dec. 1882, p. 543.

I have previously alluded to the resemblance in the teeth and in the shape of the body which this species bears to the little *Uronemus lobatus* of the Burdiehouse Limestone; resemblances which have impressed me so much of late that I have resolved, in the meanwhile at least, to give up *Ganopristodus* and add the species to *Uronemus*. Here I may also state that I have years ago abandoned *Uronemus magnus* from the Airdrie Blackband Ironstone, as I believe the fossil to which I gave that name[2] to be a fragment either of *Ctenodus* or *Hemictenodus*.

Uronemus, if the species *splendens* be adopted as an exponent of its structure, is a genus of great interest, as it shows us a fish which we may safely put among the Dipnoi, but whose dentition does not take the form of Ctenodont or Ceratodont plates. Nevertheless the teeth of *Uronemus* closely resemble in general appearance the denticles on the coronal ridges of *Dipterus*, and of young specimens of *Hemictenodus obliquus*.

Since my last notice of this species was written I have obtained several specimens of the cranial roof, from which it turns out that the constituent plates were arranged much as in *Dipterus* and *Ctenodus cristatus*. The median occipital is in contact with three lateral pairs of plates, the anterior pair meeting in the middle line in front, and there is another very small median plate in front of this pair, but separated from the median occipital by a considerable interval.

IV.—Note on the Airolo-Schists Controversy.

By the Rev. A. Irving, D.Sc. (Lond.), F.G.S.;
of Wellington College, Berks.

From one cause and another efficient education in modern languages has been exceptional in this country until quite recent years; and so it is no reproach to the geologist for him to have to confess that he "can't read German." He must therefore get some friend to translate for him, or wait until translations of many important papers and books are published; and in many cases this never happens. So it is thought that towards the present controversy, which has been raised about the schists, etc., of the Val Bedretto and the adjoining districts, the mental attitude of many

[1] Nature, 1878. [2] Geol. Mag. Dec. II. Vol. I. 1874, p. 555.

geological students may be pretty much that of the Bavarian veteran.[1] It is with the hope of throwing a little light on the subject that the present writer has put pen to paper. For it is not too much to say that the subject is one of critical importance.

The appearance of Dr. Heim's great work[2] on the Tödi-Windgällen Group of the Central Alps marked almost a new departure in the investigation of the forces employed by nature in mountain-building. In some of his theoretical views drawn from the facts described in that work Heim had been anticipated by Prof. Suess of Vienna,[3] and the priority is generously acknowledged. The work is well known; but the student needs to be warned against the false inferences on some points which he will probably draw from the sectional descriptions in the *Atlas*, if he omits to study the corresponding portions of the text of the work. If anything could exceed our admiration for this splendid contribution to physical geology, it might be that which we all felt for the magnificent series of transverse sections of the Alps—the work of Prof. Heim and his pupils at Zürich—exhibited in the temporary Museum of the International Geological Congress at Burlington Gardens in September, 1888. In his recent little work[4] the present writer has discussed many of the facts furnished by Dr. Heim in their bearing upon questions connected with the metamorphism of rocks. In his Essay on the Crystalline Schists,[5] in 1888, Heim indicates clearly the extent to which he is prepared to go in applying the principles of 'dynamo-metamorphism.' He expressly warns geologists against rash generalizations in the direction of "regional pressure-metamorphism," from the exceptional and abnormal structural facies presented by those Alpine masses, which he knows most intimately, and has described in such a masterly way in his great work. It is unnecessary to occupy space here with quotations, since a translation of Dr. Heim's essay has been published.[6]

Dr. Heim's letter, a translation of which was read by Dr. Geikie at the meeting of the Geological Society on the 22nd of January, 1890, seemed to contain little but what those who had made a study of his great work were familiar with before. But if it served no other purpose, the publication of that letter is most opportune as a reply to some remarks in a recent Number of the GEOLOGICAL MAGAZINE.[7] J. J. H. T. may learn from it that, by the Swiss geologists at least, the "primitive crust of the earth" is not by any means regarded as a "geological Will o' the wisp." Dr. Heim's own

[1] "It was the English," Kaspar cried,
"Who put the French to rout;
But what they fought each other for,
I could not well make out."

[2] *Untersuchungen über den Mechanismus der Gebirgsbildung.*

[3] *Die Entstehung der Alpen*, a work of great value and interest.

[4] *Chemical and Physical Studies in the Metamorphism of Rocks* (London, 1889).

[5] See *Etudes sur les Schistes Crystallins*, published by the International Geological Congress (London, 1888).

[6] See *Nature*, vol. xxxviii. Sept. 27, 1888.

[7] Decade III. Vol. VII. (January, 1890), p. 36. Prof. de Lapparent's *L'Écorce Terrestre* (Brussels, 1888) is worthy of consideration.

formulation of his ideas on this subject in this letter shows that he has seen no reason to depart in any essential matters from the diagnostic contrast, which he drew some twelve years ago, between the rocks of the *Central Massif* (viewed as a great crystalline complex) and the rocks of the flanking ranges of the Alpine Chain.[1] Von Hauer (as representing the Austrian geologists) and Credner (as representing those of Germany) may be cited in favour of the same view. So that one is at a loss to understand what people can mean, when they attempt to depreciate the results of the microscopic and field work of such a worker as Prof. Bonney by charging him with "holding exceptional views,"[2] in maintaining the existence of a great Archæan complex with an individuality (so far as the broad general facies are concerned) altogether its own, in contrast with any great *complexus* of rocks of later age. Why even Heim does not venture to speak of the Palæozoic rocks of the Tödi-Windgällen Group (as a series) as anything more than 'half-crystalline';[3] yet this is perhaps the most powerfully compressed and contorted region of the whole Alpine system. Eliminate the local and exceptional structural features which are met with, resulting in some cases from contact-metamorphism, sometimes from excessive pressure and shearing (*e.g.* in the Tödi-Windgällen Group), at others from the detrital material derived from the central crystalline massif being exceptionally siliceous and crystalline,—and you get a great sedimentary series flanking the whole Alpine Chain quite distinct from the Central Massif. This seems to be Prof. Bonney's view; and this the foremost of living Swiss geologists has declared to be the view still held by him and his *confrères* in the year 1890.[4] And so the authors of this flank-attack upon Dr. Bonney's work seem to have impaled themselves upon the horns of a pretty dilemma! This is certainly rather 'sensational' for them.

Now it must be distinctly borne in mind that Heim's descriptions of the rocks of the Central Alps are almost entirely based on *macroscopic* examinations and field observations; and he himself emphasizes the desirability of a detailed (durchgehend) *microscopic* examination.[5] *This it is which forms the chief strength of Prof. Bonney's position.* For the Swiss geologists are rather late in the field with this branch of research; and, while they have been lagging behind, other cases of alleged "reduction of rocks of later date to the condition of crystalline schists,"[6] have been exposed and condemned on a closer examination with the microscope.[7]

The late Prof. R. D. Irving[8] defined a typical crystalline schist as "a rock of completely crystalline interlocked texture, which is

[1] *Op. cit.* Bd. ii. p. 40. See also *Chem. and Physical Studies*, pp. 89, 124.
[2] Q.J.G.S. February, 1889, p. 109. [3] *Op. cit.* Bd. i. pp. 41–52.
[4] From a conversation which the present writer had with Dr. Heim over his sections in September, 1888, it has seemed all the way through this controversy that the real difference between Heim and Bonney has been much exaggerated.
[5] *Op. cit.* Bd. i. p. 43. [6] Q.J.G.S. *loc. cit.*
[7] See (*e.g.*) 'A supposed case of metamorphism of an Alpine rock of Carboniferous age,' GEOL. MAG. Decade II. Vol. X. pp. 507-511.
[8] *Etudes sur les Schistes Crystallins*, p. 93.

possessed of a schistose parting due to a parallel or foliated arrangement of the mineral ingredients, or of aggregations of those ingredients." This is about as satisfactory a definition as has yet been given. And he complains[1] that after the name 'metamorphism' was applied to undoubted masses of a clastic origin which had acquired a certain amount of schistosity ("a vague naming of an unexplained process rather than an explanation"), it was loosely and generally carried over to all classes of crystalline schists, whether anything was known about their original condition or not.[2] "No serious effort was made to trace them into unquestionable sedimentaries, and when the attempt was made later it was found impossible to do so." When then we begin to discuss a 'crystalline schist,' we are treading on slippery ground, unless we agree on some definition beforehand. We cannot tolerate the construction of a definition to suit the exigencies of a special case; yet it is not too much to say that Mr. Teall was caught in this fallacy in the discussion of Prof. Bonney's paper, at the Geological Society, on 22nd January, 1890.[3] He enumerated certain characters, which the altered Belemnite-bearing rocks of the Nufenen Pass exhibit under the microscope; but they do not satisfy the requirements of such a definition of a crystalline schist as has been quoted above. At the same time he frankly admitted that he had found on examination that "the garnet-schists are quite different from the Belemnite-rock." No one can therefore doubt that Prof. Bonney was standing on very firm ground when he "gave a complete contradiction to any statement that these fossil-bearing rocks are in any proper sense crystalline schists," and asserted that the similarity between these and certain undoubted crystalline schists of Val Canaria and Val Piora was only superficial, as "under the microscope the differences were at once visible," the two series of rocks having a totally distinct facies. All the details of the evidence on which these statements are based will appear when Dr. Bonney's paper is published.[4]

If we may judge from one of the first instalments of detailed work in microscopic petrography which the younger school of Swiss geologists have produced, we have certainly in the recent monograph of Dr. Grubenmann, of Frauenfeld,[5] the earnest and the promise of a rich harvest in microscopic petrography in the near future. There is a thoroughness about Grubenmann's descriptive work, from his combining the threefold method of field-observation, microscopic examination, and chemical analysis, which is most satisfactory. The pity is that we cannot say as much for the logical soundness of his conclusions, and their bearing upon questions of general theory.

[1] *Op. cit.* pp. 94, 95.

[2] At a previous meeting of the Society the present writer entered his protest against this assumption (Q.J.G.S., August, 1889, p. 503).

[3] See "Abstract of Proceedings of the Geological Society," No. 549.

[4] That paper having been now (May 19) published, this is found to be so.

[5] "*Ueber die Gesteine der sedimentären Mulde von Airolo*," by Dr. Ulrich Grubenmann (Frauenfeld, J. Huber, 1888). I have to thank Dr. Heim for drawing my attention to this, and Dr. Grubenmann for his prompt courtesy in sending me a copy; and I offer beforehand most ample apologies to the latter, if anything in this paper may appear to him at all discourteous (etwas unhöflich).

Dr. Grubenmann works out a section in the Val Canaria (a gorge-like valley cut into the north slope of the Val Bedretto and across the main strike of the beds) on the south flank of the great Gotthard *massif*. Of this the following may be taken as an outline (the numbers denoting the ascending orders of the rocks on the mountain-flank) :—

THE VAL-CANARIA SECTION (AFTER GRUBENMANN).

7. *The Uppermost Zone of 2-mica Schists* : containing below whitish and green mica-scales, dark green biotite, increasing in the upper part until the proportions of white and dark mica become nearly equal. From this point the section passes upwards into the "amphibole- and garnet-bearing schists of the southern schist- and gneiss-zone of the Gotthard massif." In addition to quartz and calcite, microscopic examination shows them to be tolerably rich in small black mineral particles (magnetite ?), along with pyrites, hæmatite, and (sparingly) rutile. Tourmaline and zircon occur as accessory minerals (thickness ?)

6. *The Upper Zone of Gypsum, Rauchwacke, and Dolomite* : exposed in a wild gorge difficult of access (previously described by von Fritsch), but furnishing, in the insoluble residues after prolonged treatment with acids, margarite, biotite, quartz (in grains), tourmalines, rutiles, and zircons (thickness ?)

5. *The Second Zone of 2-mica Schists (containing disthene)* : comprising—

(*a*.) Dark-grey, coarse, stratified calc-mica-schist = 4 metres.

(*b*.) Calcareous and ferruginous quartzite (thickness ?)

(*c*.) A 2-mica schist (very feebly stratified), of grey colour and pearly lustre, apparently much slickensided (as of a 'shear-zone'), containing, besides the two micas, rutiles, tourmalines, quartz, calcite (sometimes as a pseudomorph after zoisite), an opaque black mineral (with limonitic covering of the grains), earthy clay material = $1\frac{1}{2}$ metres.

4. *The Kalkglimmerschiefer*[1] *(calc-mica-schist)* : a clear-grey argillaceous schistose limestone, with quartz grains, with light and green mica-scales on the foliation-planes and a talcose mineral adhering to the quartz-grains, interlaminated with feeble layers of a micaceous quartzite (half-schistose, half-granular), and of strongly ferruginous quartzite, terminating upwards in a bed of marble ($1\frac{1}{2}$ metres) = 300 metres.

3. *Garnet-bearing Schists (Thonglimmerschiefer)* : interstratified with quartzite, and falling into three principal groups :—

(*a*.) An upper group of dark grey schists (4 metres).

(*b*.) A grey brown granular quartzite with included mica, 'opaque Erzmassen,' pyrite, and amorphous limonite (10 metres).

(*c*.) A lower group of brown highly lustrous schists (1 metre). The schists contain *garnets* (often greatly deformed by pressure), two micas (probably margarite and biotite), quartz particles, tourmalines, rutiles, and zoisite.

[1] 'Calcitglimmerschiefer' of Kalkowsky, *El. der Lith.* p. 199.

2. *The first (lowest) zone of 2-mica Schists*: grey-green to dark-green, becoming in places talcose and chloritic, very lustrous, containing, here and there, in addition to the two micas, lamellæ of disthene, also quartz-veins accompanied with calcite and kyanite; the single bands of schist not generally exceeding 5 cm. (2 in.) in thickness. Tourmalines, rutiles, zircons, zoisite, and magnetite are met with in these schists. (2 metres.)

1. *The lower zone of gypsum, rauchwacke, and dolomite*: in the gypsum occur quartz, pyrite, mica, talc, tourmaline, disthene, and a few zircons; in the dolomite, fragments of glassy quartz and calcite.

So far as the detailed descriptive work of Dr. Grubenmann goes, it is simply admirable; it is in the interpretation of the facts, as pointing in the direction of a general theory of 'dynamo-metamorphism,' that we feel compelled to part company with the author, and that for the following reasons:—

(1.) The assumption[1] that these rocks all belong to one and the same complex (Schichtenreihe) seems to be quite arbitrary, since in such a highly disturbed and deformed district as this[2] their present juxtaposition may be (and probably is) merely accidental.

(2.) Although the garnet-bearing schists of the Val Canaria have been well worked out, the author, in identifying them with the altered rocks (containing Belemnites) on the Nufenen and Gries Pass to the west, and of Fontana to the east, has fallen into a fatal error, from not testing the spurious knotty structures in the limestones, which in the pre-microscopic days of petrology were described as *garnets*. On Prof. Bonney's closer scrutiny of them this identification breaks hopelessly down. These knotty structures are found to belong to a very low order indeed of silicates, and are admittedly not garnets at all. There remains, therefore, no evidence that these garnetiferous 'schists' are of Jurassic age.[3]

(3.) If it be admitted that the dolomites, rauchwacke and gypsum are of Triassic age, this tells us nothing about the age of the schists with which they are in accidental juxtaposition; since by Dr. Grubenmann's own showing the insoluble residues of the gypsum contain minerals furnished by the weathering of the schists. Whatever therefore the age of the schists, they must be certainly much older than the gypsum. But the examination of the district by Dr. Bonney and Mr. Eccles has brought to light even more cogent evidence than this; for they find that the dolomite is frequently brecciated, and that the included fragments are derived from these very schists (with their characters well preserved), which are supposed to be younger than they. It is somewhat strange that such evidence has been overlooked, or ignored by Dr. Grubenmann in compiling his memoir.

(4.) In the assumption that certain markings in the calc-mica-schists in Val Piora, observed by Escher v. d. Linth many years ago,

[1] *Ibid.* p. 3.

[2] See published sections of the Gotthard Tunnel by Dr. Stapff; Prestwich, *Geology*, vol. i. p. 304, section i.

[3] See Grubenmann, *Ibid.* p. 17.

were "indeterminable (unbestimmbare) but undoubted (unzweifelhafte) organic remains,"[1] the author appears to have been leaning upon the 'broken reed' of mere *macroscopic* observation. This also gives way on a closer microscopic examination, as Prof. Bonney has not much difficulty in showing.

(5.) We have no right to assume, as the author does,[2] that the calc-mica-schists are rocks "which were first deposited at the bottom of the sea as limestones by the agency of organisms (durch Vermittelung von Organismen)." The present writer has shown elsewhere[3] that such assumptions are unnecessary and highly improbable for the crystalline marbles, calc-schists, and the quartzites of the oldest series of rocks. They can be accounted for in a very different way. A stratigraphical difficulty which such an assumption raises was pointed out by Mr. Eccles in the discussion of Prof. Bonney's paper; a difficulty which the present writer's own observations in the Alps enable him thoroughly to appreciate.

(6.) The inconstant relation of the dolomite, etc., to the schists and gneiss of that region of the Alps, and the extremely fresh and unaltered condition of the dolomite deprives it of all value as evidence of the age of the schists in juxtaposition with which it is accidentally found in the Val Canaria section.

(7.) In face of the evidence now to hand, it is impossible to recognize such a succession as is implied in the following proposition:[4]—"It is scarcely far from the truth, if in the original area of the sedimentary trough (Mulde), the anhydrite and gypsum is regarded as the deeper or older, and the argillaceous limestones as the upper or younger portion."

And a further difficulty arises when we attempt to plot out the section as a 'Doppelmulde' or double infold with a central anticlinal,[5] since there is no apparent symmetry between the two synclinals which are supposed to have entrapped the two dolomite groups of rocks. Moreover, the occurrence of the 2-mica schists (zone 7 of Dr. Grubenmann's section) outside the supposed Doppelmulde is strong evidence against the younger age of the same schists as they occur in zones 2 and 5.

(8, lastly.) The suggestion[6] that, "in those zones where the dolomites and argillaceous limestones are mashed into one another, the molecules in contact might, under enormous pressure, form margarite and meroxene more abundantly and produce the 2-mica schists," is seen to be worthless, from the fact that, while the 2-mica schists occur *three* times in the section, it is only in *one* instance (zone 5) that they occur between the dolomite and the supposed *quondam* limestones. And the further suggestion[7] that the garnets may have been fabricated by the combining together (Zusammenscharung) of molecules of silicates of lime and alumina is still more improbable. Even if the schists could be shown to be

[1] *Ibid.* p. 19.
[2] *Ibid.* pp. 24, 25.
[3] *Chemical and Physical Studies*, etc., pp. 7–13.
[4] Grubenmann, *Ibid.* p. 25.
[5] *Ibid.* p. 25.
[6] *Ibid.* p. 26.
[7] *Ibid.* p. 26.

of Mesozoic age (a position very far from established), a much more rational account could be given of the garnets, etc., as derived (allothigenous) minerals.[1]

The case seems to break down hopelessly, and with it this last desperate sally of the upholders of the extreme orthodox doctrine of the followers of Hutton and of his still more illustrious exponent of our own time. Science truly hath its marvels; and marvellous it is to see this nineteenth century drawing towards its close, while distinguished English geologists are 'dealing blows in the air' in defence of their pet doctrine of 'uniformitarianism,' first propounded by a most worthy and illustrious man, who lived and died when modern chemistry was as yet in its infancy, when spectrum analysis as applied to cosmical physics was not even dreamt of, when thermal chemistry was unknown, and men like Joule had not done their work and written their names on the muster-roll of Fame.

Supplementary Note (May 1st).

A great deal has been made of late in some quarters of the facts described by Dr. Lawson (of the Canadian Survey) in his paper[2] published by the International Congress of London in 1888. It has been proclaimed to the world that these afford evidence of an *igneous* origin (igneous in the plutonic sense) of the Laurentian gneisses. And yet, strange to say, they do not perceive that this is (if not an utter capitulation) a surrender of the greater half of the field by the metamorphic school. They are recognized in fact as being crystallized portions of the original magma, which was once subjacent to the earlier and thinner crust (the schists). I do not mean to say that this is admitted in so many words; but substantially it is admitted. I saw this very plainly in September, 1888. I communicated my ideas to Dr. Lawson in conversation; and in a footnote to page 68 of my "Chemical and Physical Studies," 1889, I gave this as a direct deduction from the principles of metataxis contended for in that work. I pointed out that, "As the outer zone of the lithosphere solidified through the dissipation of energy by radiation, the tidal movements still continuing, huge masses (even 'regional' masses) of the solidified outer 'crust' would *slide over the viscous magma beneath*, as the strain produced by tidal movements in the latter caused huge fractures here and there in the crust. As the magma grew more and more viscous, it is certain that under such circumstances huge fragments of the thin crust would be torn away, imbedded in the magma, and transferred in some cases to considerable distances. This seems to be the most natural explanation of the striking facts observed by Lawson in the Laurentian gneiss, and described by him in his Essay."

The facts referred to are set forth in much fuller detail in the Official Report since published, which is a very fine piece of work, as I know, from the copy which Dr. Lawson has been good enough to send me. Since the publication of that Report, Dr. Lawson has

[1] See *Chemical and Physical Studies*, etc., Appendix II. note T.

[2] Vide *Etudes sur les Schists Crystallins*, pp. 66–88.

seen his way to the adoption of what is substantially the explanation offered by myself. In a paper read before the Geological Society of America[1] (dated March, 1890), he says, in speaking of the *Significance of the Relationship* [of the gneiss-series and the schist-series]: —"Bearing in mind the essential distinctions which exist between the rock-formations of the Ontarian[2] and Laurentian systems, both as to their lithological character and their mode of occurrence, and remembering also their relative geographical distribution,[3] the relationship which obtains between the two systems leads clearly and unavoidably to this conclusion, viz. that the formations of the Ontarian system at one time rested, as a volume of hard rocks, upon a magma which subsequently crystallized as the Laurentian granite-gneiss; so that the present line of demarcation between the two systems must be regarded as representing the trace of what was once a plane of contact between the thin crust and the magma upon which it floated.

"This conclusion affords a conception of the Archæan which is ideal in its simplicity, and which gives us the key to the ravelling of the mystery in which the subject has been involved. The fact that the crust, which constitutes what we now call the Ontarian, was crumpled while it floated on the magma; the fact that its lower portions were shattered by disturbance, so that the magma penetrated the fissures and inclosed detached fragments; the fact that there were currents in the magma which arranged the inclusions in streams and so produced the foliation of the gneiss; the fact of contact-metamorphism;—all these are incidental and concomitant circumstances of the great essential condition of a crust resting on a magma."

[See a most excellent Review of Dr. Andrew C. Lawson's Memoir on the Geology of the Rainy Lake Region (being Part F, of the Annual Report of the Geological and Natural History Survey of Canada for 1887), in the GEOLOGICAL MAGAZINE for January, 1890, Decade III. Vol. VII. pp. 36–39.—EDIT. GEOL. MAG.]

V.—PHYSIOGRAPHY OF THE LOWER TRIAS.

By T. MELLARD READE, C.E., F.G.S.

FREE discussion is a valuable aid to research when entered upon in a proper spirit. I am glad to see the contribution of Mr. Jukes-Browne to this subject, together with the letter from Prof. Bonney, in the May Number of the GEOLOGICAL MAGAZINE.

Having put forward a theory of the origin of the Lower Trias, I cannot object to its being tested in every way; so in this spirit I will proceed to answer as best I can the criticisms which it has called forth.

It appears to me that Mr. Jukes-Browne has scarcely grasped the

[1] See "Bulletin of the Geol. Soc. of Am." vol. i. pp. 175–194.

[2] An inclusive term now proposed for the Upper Archæan [= Coutchiking and Keewatin series.]

[3] Lawson estimates the Upper Archæan as easily 9 miles in thickness; but they are small in extent compared with the gneiss series.

significance of the examples of tidal action which I gave in my last paper.[1] The quotation there given respecting the "remarkable ditch" scooped out by the tide opposite Wigtonshire is in Captain Beechey's own words. That very efficient and scientific officer had no theory to uphold; but the cause and effect were so clear to him that he speaks without hesitation. I had marked years ago (1873) on a large Admiralty Chart the stream tide lines taken from Captain Beechey's survey, and this "remarkable ditch" is in exact parallelism to them. There is also another striking example of excavation by the tide at the northern entrance to the Irish Sea confirmatory of this view. Opposite and north of Rathlin Island there is a "deep" in which the greatest sounding is 133 fathoms = 798 feet, the surrounding sea-bottom being from 60 to 80 fathoms only. A portion of the bottom of this depression at a depth of 105 fathoms or 630 feet is rock, while the surrounding soundings in the shallower water are sand and shells, a clear proof that the "deep" has been excavated.

Hurd "deep" opposite the "Casquets" in the English Channel is another example of a long narrow channel where at a depth of 73 fathoms the bottom is rock, and at 95 fathoms sand and stones, the surrounding bottom being from 30 to 40 fathoms only. The form of the bottom of the sea below the depth at which wind waves act is the resultant of the rub of the tide on the bottom at one place and deposition of the eroded material at another.

According to a letter received by me from Sir G. B. Airy, the Astronomer Royal in 1873, the difference between the surface and bottom velocities *is the measure of the work done by the tide on the bottom.*

I think I may be excused repeating these facts and principles, as I regret to say that the subject has hitherto received little attention from geologists.

Mr. Arthur R. Hunt (Geol. Mag. April, 1890, pp. 191-2) goes so far as to assert that the tides in the English Channel, taking it as a test case, have no effect on the bottom at all, "that they are incapable by their own unassisted efforts of raising the sand," and if I understood him aright, bases his opinion upon the existence of molluscs in the channel which could not live did the tides in any way disturb the sands! Curiously enough, I read in *Nature* (April 19th, p. 569) shortly afterwards that Major Reinhold, in a paper on the botanical condition of the German Ocean read at a meeting of the Natural History Society of Kiel, states that, according to researches recently made, the Eastern part is almost wholly bare of vegetation. "This is believed to be owing to the strong tidal currents which so disturb the sea bottom as to prevent the germs and spores of marine plants from settling."

The Admiralty Chart of the English Channel shows a bottom in many places composed of stones or gravel, or sand, stones and gravel, at depths below the influence of wind waves; so, if we accept

[1] Geol. Mag. April, 1890.

Mr. Hunt's views, we must also be prepared to believe that the bottom is now exactly as it was when first submerged, an opinion in which he will not get many geologists to support him.

Though not a naturalist, I happen to live on a coast in which the combined action of the wind and tides are continually disturbing the sand banks and the channels and the sandy shore, and thousands of molluscs—I might almost say millions—are dug up during a storm and cast on the shore; yet sufficient remain to keep up the "breed" so to say.

If molluscs can live under these conditions in the Estuary of the Mersey, why not in the English Channel? I may be therefore excused for thinking that their existence in the English Channel proves nothing respecting the tides either one way or the other.[1]

In the Mersey, between Liverpool and Birkenhead, we have a striking instance of the excavating power of the tide. At one point over the Mersey Tunnel, as proved by divers, the rock was bare, with great boulders lying upon it derived from the destruction of the Boulder-clay. It would be wearisome for me to go on multiplying these instances; suffice it to say that the form of the Mersey bottom is evidently due to tidal rub.

I have thought it necessary to detail these instances of the effects of tidal action, as, if the tides are physically incapable of producing the effect I attribute to them, viz. the current bedding of sandstones and the rolling of pebbles as seen in our typical Bunter, my theory is invalid.

As regards Prof. Bonney's criticism, from the known attention he has given to this subject his views no doubt deserve the greatest consideration. I am, however, compelled to say that I fail to see why the Lancashire Bunter, which is of great thickness (proved to 1200 feet), and occupies a large area, should be looked upon as anomalous, and our attention be restricted to conglomerate beds of 60 feet in thickness. These beds occur in the Midland Counties, and may have been shore deposits, as suggested by Mr. Jukes-Browne. I expressly said in my last communication that my theory does not exclude shore action. How can there have been seas and embayments without shores?

There are, however, no evidences of littoral deposit in any of the Bunter of Lancashire and Cheshire that I have seen; and this it was partly the province of my theory to explain.

It seems, however, I am expected to sketch out the physical geography of the Triassic period, and localize the communications of the Triassic Sea with the Atlantic Ocean. Surely this is making a

[1] Mr. Hunt asks, "Would Mr. Mellard Reade give his reasons for believing that waves ever cause surface particles in deep water to move in a vertical circle, or an ellipse, not very different from one having the longer axis vertical?" If Mr. Hunt will watch a cork floating in water on which wind waves are generated, he will, I think, see that the vertical oscillatory movement of the cork is as great as or greater than the horizontal. The composition of the two movements will give either a circle or an ellipse. This is no discovery of Mr. Reade's, but a fact known to every physicist.

considerable demand upon me, and in the slang of the day is what is called "a big order." I am not even prepared to say that there was then an Atlantic Ocean in the sense that we understand it now.

The possibilities of the physical geography of the period are so great that I see no difficulty in the origin of a tidal wave in an open ocean, and its propagation through the embayments or channels in which I suggest the British Trias was laid down. Even in the North of Ireland, in the neighbourhood of Carrickfergus on Belfast Lough, the Trias is estimated at 2000 feet thick.[1] On the other hand, on Slieve-Gallion-Carn, west of Lough Neagh, the Keuper is found at an altitude of 1200 feet above the level of the sea.[2]

How can we in view of such facts as these aver that the English Trias was laid down in a basin with shallow entrances? On the other hand, as I pointed out in my original paper read before the British Association (GEOL. MAG. December, 1889), there are the possibilities of the extension of the Trias to the eastward under the newer rocks.

We are dealing only with *remnants*; we have not materials now to reconstruct the physical geography of the past with any degree of accuracy; but we know enough of the manner of occurrence and extension of the Trias, of which the Bunter is one phase, to make it difficult, for me at all events, to see how its distribution can be explained by river action.

I devoted a fortnight last summer to an examination of the Trias of the Vale of Clwyd. At none of the sections I visited, and I saw most, could I detect the presence of local materials unless it were some of the marly material binding the grains. There were no pebbles, either quartzite or otherwise, in the sandstones which are considered to be Lower Bunter, but much persistent current bedding. This *crux* is explained by tidal action, which in a *cul-de-sac* would have less force than in the channel (now occupied by the peninsula of Wirral) between the mountains of Flintshire and the Carboniferous hills of Lancashire, forming a communication between the Triassic area covered by the Irish Sea and that of the Midlands. It is on these stream lines that the greatest development of the pebbles of the Bunter of Lancashire and Cheshire occur.

Prof. Bonney naturally lays great stress upon his identification of some of the pebbles of the Trias with those of the Highland rocks.

While giving due weight to his opinion on this point, such identifications can scarcely be put in the category of absolute certainties.

There is also another explanation of their presence volunteered by Mr. Jukes-Browne, who suggests that they may be only indirectly derivative from the Western Highlands of Scotland, even if that were their original home. It is the increase in the number of and size of the pebbles towards the Midland Counties that makes it difficult to conceive that they came from the North.

[1] Kinahan's Manual of the Geology of Ireland, p. 138.
[2] *Ibid.* p. 141.

VI.—Note on the Occurrence of the Tunny (*Thynnus thynnus*) in the Cromer "Forest Bed."

By E. T. Newton, F.G.S., F.Z.S.

Mr. R. Storms has recently described (Bull. Soc. Belge Géol. vol. iii. p. 163, 1889) the vertebræ of a large Tunny from the Antwerp Crag, which he has named *Thynnus Scaldesii*, and Mr. A. Smith Woodward, in the April number of the Annals and Magazine of Natural History, records the same species from the Coralline Crag of Suffolk; it is especially interesting, therefore, to be able at this time to notice the occurrence of the common Tunny (*T. thynnus*) in the Cromer "Forest Bed."

Early in the present year, Mr. A. Savin, of Cromer, found in the "Forest Bed" of East Runton a large Teleostean fish-vertebra, which he sent to me for identification, and which agreed so closely in all its characters with the nineteenth vertebra of the large Tunny in the Museum of the Royal College of Surgeons, that I had no hesitation in referring it to the same species. This vertebra has lost all its processes, but the centrum now measures 43 mm. long, 53 mm. wide, and 45 mm. high; it is deeply biconcave and somewhat depressed; it is further characterized by a single large longitudinal bar on each side, which thickens anteriorly and posteriorly, a roughened space towards its front part indicating the point of attachment of the rib. Above and below the bar is a deep fossa.

The nineteenth vertebra of the Tunny in the College of Surgeons measures 49·5 mm. long, and 60·5 mm. wide, a proportion of length to width almost exactly that of the Forest Bed specimen.

It was intended to reserve the notice of this species for a forthcoming memoir of the Geological Survey, but the publication of Mr. Smith Woodward's account of the Coralline Crag *T. Scaldesiensis* seemed a fitting opportunity to make known the occurrence of the recent species in the uppermost beds of the English Pliocene. After a re-examination and comparison of the Forest Bed vertebra with the recent form, and also of the Antwerp and Coralline Crag specimens, I am quite of opinion that the Crag fossils are specifically distinct from the living *Thynnus thynnus*, but am confirmed in my identification of the "Forest Bed" vertebra with the latter species.

VII.—Notes on the Probable Origin of Some Slates.

By W. Maynard Hutchings.

Mr. Sorby, in his Address as President of the Royal Microscopical Society in 1877, dwelt very forcibly on the interest and value attaching to researches into the original nature of the materials composing sedimentary deposits, and stated that, so far as he was aware, but little had been done in this direction by means of the microscope (Monthly Microscop. Journal, vol. xvii.).

Since Mr. Sorby delivered that address much has been done in this direction, both by workers in this country and on the Continent, and more especially with regard to slates and allied rocks. But

much still remains to be done before we are able, in a satisfactory manner, to read in the slates, shales, sandstones, etc., the record of their origin and subsequent development; and so, as Mr. Sorby says, to "as it were, sometimes trace back the genealogy of our globe a generation or more earlier than by other means."

The following notes, resulting from considerable study of some of the materials in question, have only a limited bearing on a limited portion of this very wide subject, but are offered in the hope that they may not be wholly wanting in value as a contribution towards explaining some of the questions involved.

During the examination of a series of sections of slates (roofing-slates and closely similar material from Wales and Cornwall), two or three special points of interest arose which led me to wish to study in detail some more recent deposits, which might show less advanced stages of the chemical and morphological changes which have taken place in the original sediments. At the same time I specially wished to have deposits as to which one could be quite sure that they were derived from the waste of granite areas. Materials answering these requirements are to hand in the Carboniferous formation, and especially in the Coal-measures, the sandstones, shales, etc., of which are, I think, usually considered to have been derived from granites, and this has certainly been the case with some of them that I have worked upon.

Some of the observations made appear to have sufficient bearing on the eventual development of certain slates to warrant a rather detailed account of them.

I will select for description the materials of a bed exposed in the cliffs near the village of Seaton, a few miles north of Newcastle-on-Tyne. This bed, several feet thick, is composed mainly of indurated clay of various degrees of fineness. The finest does not show to eye or pocket-lens a flake of mica or a grain of any sort of sand, and yields when ground with water a clay of the highest degree of smoothness and plasticity. Bands of this alternate with others in which more or less mica is seen with the naked eye, and which, while still fully plastic with water, contain a good deal of gritty sand. These again pass into still coarser layers, while here and there are bands, some inches thick, of fine-grained, laminated, soft micaceous sandstone. There are also, at places, very thin bands of clay-ironstone. Lamination is not so well marked in the finest clay as in the coarser and harder bands, where it is highly developed; such bands verging in nature towards soft shales.

The greater part of the bed in question is really a more or less coarse-grained "fire-clay," similar in all respects to the fire-clays worked on a large scale in the district, differing only in the mode of occurrence, the regular beds, with the seams of coal, being mostly more or less unstratified and irregular.

Above the bed just described is one of several feet of micaceous sandstone, followed by a series of several feet of clays, soft shales, and sandstones, with a very thin seam of coal; and finally a considerable thickness of hard compact sandstone. The whole has

undergone some considerable disturbance, having been thrown into folds, while at several points the clay beds are faulted and puckered.

Some of the coarser, harder, more micaceous deposit was taken out and subjected to detailed examination. Sections were prepared of it, and its component minerals were also separated, as far as practicable with materials of this nature, by levigation and by use of Sonstadt's solution.

It is of the greatest importance to always, whenever possible, study clays, soft shales, etc., mounted as continuous sections as well as in crushed form in water and balsam. It is only by so doing that the relationship of the various constituents to each other can be properly observed. Even with quite soft clays it is practicable to prepare sections; or perhaps the word "section" hardly applies in such cases, and one might call it a continuous layer or film.

The material, well dried but of course never so heated as to lose any of its *combined* water, may be cut into pieces of suitable size with a knife, levelled off on a hard rough surface (good emery-cloth does excellently), brushed clear of dust and smoothed, without water, on a ground-glass plate; then warmed again and cemented in the usual way to a slide. The piece, which must be thick for the foregoing operations, is now cut down with a knife, rubbed down pretty thin on emery-cloth and finished by very careful work, with water only, on a glass plate.

Exceedingly thin films may be got in this way, but the outer edges, or the thinnest margins of holes that may have been worn here and there, will be found of most value for the examination of fine-grained clays under high powers.

Sections of the material in question show that it is made up mainly of mica, both muscovite and biotite, with grains of quartz and felspar, and that zircons and other accessory minerals are present.

A quantity was crushed to powder and suspended in a solution of 3·1 sp.g. The minerals which fell out were zircons, numerous and of rather large size, garnets in angular colourless fragments, crystals and fragments of rutile of the usual sort found in sands. Anatase was seen as one or two small pyramidal crystals of bluish colour, and also several beautifully perfect thin tabular crystals, pale yellow to colourless. The largest observed was $\frac{1}{350}$ inch in diameter, others being $\frac{1}{500}$ and less. They are perfectly sharp and unworn in any way, and are doubtless formed *in situ* in the deposit, as has been demonstrated of similar crystals by Thürach ("Ueber das Vorkommen mikroskopischer Zircone und Titan-Mineralien in den Gesteinen," Würzburg, 1884). There is also a good deal of tourmaline in crystals and angular fragments, and one or two grains of sphene. Further, numerous colourless, transparent, tabular crystals of rhombic shape were observed. The long diameters of the largest crystals measured were $\frac{1}{250}$ inch, but many are much smaller. The acute angle of the rhombs is 78°. An obtuse bisectrix emerges on the face of the tablets and the bi-refraction is positive. These crystals thus correspond in all respects with one of the forms of baryte (I think known as the "chisel-shaped" crystal), and taken

in conjunction with the high specific gravity they may be safely set down as being that mineral. Barium sulphate is frequently found as a deposit in colliery waters, and doubtless these crystals were formed from the solutions circulating in the sediment.

The quartz-grains average from $\frac{2}{100}$ to $\frac{3}{100}$ inch in diameter; they are in all respects of the nature of granite-quartz and are both angular and more or less rounded. Some of them I consider are *corroded*, but I confess I do not find myself able to make quite sure of this, though Mr. Sorby says that chemically corroded quartz is readily distinguished from simply worn grains.

The numerous felspar-grains are more rounded than the quartz. Many are pretty fresh; but unless cleavages or other special marks facilitate recognition, it is safer not to set down anything as felspar which does not distinguish itself from quartz by its optic figure in convergent polarized light. One or two grains of plagioclase were observed giving nearly straight extinctions,—presumably oligoclase, and one or two grains of microcline.

Mica, both muscovite and biotite, is abundant, the biotite being in excess over muscovite. The largest flakes measure about $\frac{1}{100}$ inch in longest diameter; thus one biotite flake measured $\frac{1}{100}$ by $\frac{1}{250}$ inch, and there are all sizes down to very small indeed. The muscovite is in all the distinct separate flakes seen in the sections, or isolated, in all ways fresh and normal, and shows no inclosures of any sort beyond those to be seen in granite, *i.e.* small zircons, etc.

Of the biotite the greater part is more or less altered, but the still fresh flakes show it to be optically and otherwise a quite normal granitic type.

It seems thus quite clear that in this deposit we have the waste of a granite with two micas, and I am not able to detect any grains of any sort to give rise to the inference that other rocks, older slates for instance, took part in supplying the material.

The alteration taking place in the biotite is of much interest for reasons already alluded to. Contrary to what would be expected, alteration to chlorite does not take place, or if it does, it is only to a very slight extent. A very small number of greenish flakes may be observed, but they are not chlorite. Such green flakes are seen in granites and other rocks, and may mark an early stage of the alteration of biotite to chlorite, though I believe they are in some cases looked upon as an original greenish mica. They certainly are not chlorite yet, and I have not detected any of that substance in these deposits.

The alteration which has taken place so extensively shows itself in a bleaching of the biotite and the development in it, in large quantity, of a substance of high refraction and very high double-refraction. It appears to be mainly epidote, which mineral is well known to be frequently produced during the alteration of biotite. It forms in clusters of small round or more or less oval granules, in irregular plates and flattened grains, and sometimes in plates of more definite outline, among which a few may be found as large as $\frac{1}{100}$ inch in diameter, showing the form sometimes of four-sided

rhombs; sometimes of six-sided figures by the addition of two very small faces truncating the acute angles of the rhombs. These forms correspond with the clino-pinacoidal section of epidote crystals, with which also the extinctions fully agree. Many of these aggregates of small thin plates, all parallel to the cleavage of the mica, often more or less overlapping one another, present a peculiar characteristic appearance I have not seen in epidote under other conditions.

Thürach (*op. cit.*) mentions a mineral as occurring among the débris of several of the rocks so exhaustively examined by him, which he describes as "small, light-yellow, feebly pleochroic, strongly bi-refractive crystals or rounded grains of rhombic or hexagonal form, mostly tabular and clear, often showing cracks, with a perfect cleavage parallel to the base." He quotes Klemm as having looked on these as sphene; says he himself also considered them to be that mineral, but now looks on them as "potash-mica," though, as he admits, they would not be readily recognized as such. I think there is not much doubt that what he mentions is epidote in the thin superposed tablets, resulting from biotite as just described.

Here and there, but very rarely, a few crystals of rutile are seen in the altering mica. I am of opinion that rutile in granules is also formed with the granular epidote, though it is not possible to make sure of it. I have seen in some Cornish and other altered sedimentary rocks just such clusters of rounded grains of rutile, with short and comparatively blunt *crystals* of that mineral under conditions which lead me to the belief that under the influence of dynamic metamorphism the rounded grains are capable of taking definite crystal form.

The bleaching which accompanies this development of epidote in the biotite is attended also by a rapid loss of the optic properties of the mineral,—its strong bi-refraction and its figure in convergent polarized light. Much of it, in large flakes, becomes so colourless as easily to be taken for muscovite when lying flat, till tested optically.

The substance of the bleached biotite seems to waste away and be entirely removed from its original position. Flakes may be seen in all stages of this removal, getting more and more indistinct, the clusters of grains and plates of epidote remaining until finally we see, throughout a section, many of such clusters without any of the original surrounding mica.

As regards the structure and arrangement of this soft shale as a whole, the quartz and felspar grains are pretty uniformly dispersed and the original mica lies mostly flat in the plane of bedding and lamination, with, however, a sufficiently large proportion lying inclined, to justify the conclusion that the deposit took place in very quiet water and was not appreciably levelled and sorted by currents. There is a good deal of fragmentary organic matter present throughout, and a good deal of limonite, diffused and in patches, which doubtless to some extent represents a part of the iron originally in combination in the biotite.

In addition to the grains of quartz and felspar and the more pronounced flakes of muscovite and variously altered biotite, as above described, the sections show the presence of another sort of component which lies in among these former, and in some parts more or less surrounds them, after the manner of a sort of ground-mass, or "paste," so to speak. It contains much that is quite indeterminable,—indistinct granular matter with specks and microlites of various sorts, and with all this a great deal of a fine, micaceous, dimly depolarizing material. In among this may be seen larger flakes of a mica which differs distinctly, in many ways, from any of the original clastic mineral.

All this is better studied in sections from a much finer-grained portion of the deposit, intermediate between that described above and the finest clay-bands. In such sections all the appearances above noted are seen, but the "paste" bears a much larger proportion to the other constituents. It doubtless represents the finest portion of the original deposit, the finest mud or silt, made up of "kaoline," the minutest powder of felspar and quartz, and the smallest flakes and shreds of mica. Throughout this "paste" (I will use the word here for convenience, though not well suited) immense numbers of minute rutile crystals are seen, the larger ones transparent, many twinned, vividly depolarizing; the smaller ones as dark, hair-like needles. Also a good many very thin small flakes of micaceous ilmenite, transparent with the characteristic shade of brown, and many very small perfect crystals of tourmaline.

There is a considerable amount of the mica[1] above referred to, evidently secondary, formed *in situ*. It is possible to trace the distinctly clastic mica, more especially the muscovite, down to very minute fragments indeed (correspondingly small biotite is not seen, as such finely divided parts are soon wholly obliterated by alteration). Then comes a point where it is often not possible to form any judgment as to whether what is seen is original or secondary. But there is much where no such doubt is called for. Flakes of various sizes, but all small, are seen, colourless or more usually pale greenish or yellowish. The larger ones blend away at their edges with the surrounding fine material in a manner which none of the original flakes of muscovite of similar size do, and they are all more or less full of the minute rutile crystals, not a trace of which occurs in any of the original muscovite. Here and there, though rarely, flakes may be got which are of sufficient size and thickness to test in convergent light. The optic axial angle is usually approximately the same as that of the original muscovite present, but in some cases it is noticeably less.

This newly-formed mica is not uniformly diffused as to its larger flakes, but the finer-grained paste in which it lies, and of which it

[1] It should be understood that by the use of the word *mica* there is no intention to infer that anything sufficiently definite is ascertainable about the substance in question to enable it to be certainly referred to any recognized variety of mica. The word is used only to express the fact that the observable characters of the mineral, including such of its optic properties as can be ascertained, bring it into close resemblance to some of our known micas.

forms a part, is everywhere seen when the sections are thin enough; and many grains of quartz and felspar, detached from the mass and separately mounted, retain a skin or coating of this paste with its secondary mica and the small rutiles, the impression produced being that the surfaces of some such grains are really attacked, as it were, by the paste and beginning to blend with it, not simply mechanically adhering.

Turning now to sections of the most fine-textured of all the bands, the smoothest finest-grained clay, it is seen that the still recognizable original minerals play a comparatively small part, the main component being the same material which is the paste in the coarser-grained beds. Biotite has wholly disappeared; original muscovite is still present throughout, though nearly all very small. But little epidote is seen; all the various indeterminable matter as before, with an increase in the amount of indistinct granular matter usually spoken of as kaoline. The entire mass is crammed with small rutile crystals and microlites, and shows all over it more or less of the small flakes of secondary mica with the inclosures of rutile, etc.

Looking, finally, at the other extreme,—the coarser bands of micaceous sandstone before mentioned, and the thicker beds of the same overlying,—these are seen to be composed of quartz, felspar and two micas as before, the biotite having been in excess. Owing probably to the greater percolation of water through this coarser material, the biotite has suffered more alteration, even in the largest flakes, than in the other bands, a larger proportion of it being wholly removed, leaving clusters of grains and plates of epidote to mark its former position. Very little fine silt of any kind seems to have been deposited during the conditions which obtained whilst these coarser materials were being laid down. There is hardly any of the rutiliferous paste to be detected anywhere, nor secondary mica; indeed, no very small mica of any kind.

Materials such as I have attempted to describe above are obtainable all over the district in natural exposures and from coal-pits, and always show the same things, as do also specimens from other and distant coal-fields.[1] I have several examples mounted illustrating the passage of such shales and clays, still showing much original biotite, into finer grades with no trace of that mineral remaining. All the fire-clays examined,—those being worked extensively for brick-making and others taken from beds not so worked,—all show the same composition and structure under the microscope, though varying a good deal in the relative amounts of sand, original mica and "paste"; and the part I speak of as paste again varies very much as to the proportion of it which consists of

[1] Among other material examined, I am indebted to Mr. G. H. Askew, of Aspatria, near Carlisle, for a series of specimens of the cores from a bore-hole put down at that place to prove the coal-seams. This series of clays, shales, and micaceous sandstones, extending to 800 feet in depth, proves to have been all derived, like the beds in the Newcastle coal-field, from the waste of a granite with two micas; and the changes undergone by the materials of the deposits have been the same.

the minutely-granular "kaoline," and of micaceous material with rutiles.

It is stated in nearly all books on the subject that clays consist mainly of hydrous silicate of alumina, and this definition is repeated, in works dealing specially with fire-clays, as true of them also. Thus Percy (Metallurgy—volume on Fuel, Fire-clays, etc.), says: "All clays as they occur in nature consist essentially of *hydrous* silicate of alumina."

This definition, derived as it is mainly from the *chemical* study of clays, is certainly not universally true, and is seldom true as to fire-clays. It is, however, very much more true in a chemical sense than in a mineralogical or petrological one. Later on in the same treatise Percy, with more of his usual caution, sums up as follows: "The conclusion, which appears to be justified by the foregoing considerations, is that one definite hydrous silicate of alumina, namely kaolinite, has been found in many instances to constitute the basis of substances usually designated clay; and in the present state of our knowledge more than this cannot confidently be asserted."

As regards the presence of kaoline in clays, it appears to me that the word is often used very vaguely. We know, of course, that kaoline, a definite hydrous silicate of alumina, is formed during the decay of felspar, and we can frequently obtain it well crystallized, as in the interstices of many grits and sandstones. In this pure form, however, it rarely, if ever, reaches deposits of clays. China-clay is usually supposed to consist most largely of it; but deposits of this clay are comparatively rare and limited, and are due, probably, largely to other causes, as well as to the ordinary atmospheric weathering of granites. And even in the purest china-clay the microscope shows the presence of a very large proportion of mica and other things. Moreover, we know that the decay of orthoclase felspar does not give rise only to kaoline, but also to mica; and, as Rosenbusch points out, we are not well able to distinguish microscopically between the two processes when in progress,—processes "which are chemically very nearly related, and depend upon a partial or total replacement of potash by water with separation of $4\,SiO_2$." It is probable that decaying orthoclase yields to denudation as much very minute hydrated mica as it does kaoline. The latter, in course of transport with water, will become reduced to impalpable granules, will be thoroughly incorporated with the finest waste of other minerals, and will finally be deposited as a very complex substance.

So far as I am able to make out, the very thinnest possible films of a "fireclay" show under a good $\frac{1}{8}$ inch objective a minutely-granular substance, usually of very faint yellowish tinge, and of such extreme tenuity that in polarized light it is either quite inactive or depolarizes only just perceptibly in a faint "speckly" manner. This granular matter is, I suppose, the mixture usually spoken of as kaoline. As soon as we examine a film a little thicker, but still extremely thin, we see between crossed Nicols a more distinct depolarizing action of the granular matter itself, and also the

presence of more or less numerous extremely small flakes of a micaceous mineral. In films a little thicker still, we usually soon reach a point where the action of the granular matter is obscured by the depolarization of this mica, much of which, when mounted in balsam, cannot be made out at all in ordinary light.

In most of the fireclays I have examined, the mica and other substances (quite apart from actual sand and coarser flakes of mica, etc.) much exceed the "kaoline." The plasticity of such clays seems, as has been suggested by some writers, to depend largely on the fineness of the particles; also probably on their physical nature connected with the hydration of the mica, because of all these clays it is true, as it is of more kaolinitic clays, that as soon as they are dehydrated, they are no longer plastic.

The universal presence of a notable amount of titanic acid in fireclays was announced by Riley in a paper published in 1862 (Journ. Chem. Soc. vol. xv.), in which many analyses are given, and where those who are not already aware of it may get full information as to the separation of titanic acid, and may see also how it comes that it is so often left undetermined in analyses of silicates.

It is now known, of course, that this titanic acid so universally diffused in clays shows itself to the microscope as crystallized rutile, for the most part.

I think it is now largely considered that in the more advanced shales, and in slates, we have the result not simply of consolidation of original deposits, but also of considerable chemical changes resulting in the formation of new minerals; and also that these changes sometimes partly commenced to take place at comparatively early periods after the deposits were formed.

The object of these notes has been to confirm this in some cases and also to endeavour to trace out, as far as may be, *what* is the course of such changes in a sediment of known origin and composition.

The development of so much rutile in the paste of these shales and clays is of interest, because none of the original minerals of the deposits contained it as such.

In the present state of our knowledge of the composition of these minerals we must be led, I imagine, to the conclusion that the biotite has been the source of this rutile. Biotite has often been proved by analysis to contain titanic acid in combination up to between three and four per cent. So far as I am aware, neither orthoclase nor muscovite has ever been shown to contain any of it. Minute dark hair-like inclosures in quartz of granites are sometimes spoken of as rutile, but apparently without definite proof; at other times they are called "schorl," also without proof, while sometimes they are spoken of first as one and then as the other, as by Mr. J. A. Phillips in his paper on grits and sandstones (Q.J.G.S. vol. xxxvii. 1881)—often on the same page. Granting that they are rutile, as is very probable, the amount of that mineral set free by the wear of quartz, and so introduced into a sediment, would be very minute; and the quartz of many granites is free from these inclosures.

The hornblende of some granites probably contains titanic acid, but its amount in most granites is not large, and in the deposits now specially considered no sign of that mineral is seen. The sphene present in granites is also in relatively very small amount, and its fragments in deposits scarce and irregular in diffusion. Probably *all* biotite of granites contains titanic acid, if only it were sought for in analysis. We know that in numerous cases rutile is seen in decomposing biotite, though it is apparently by no means a common observation; and biotites have been proved to contain titanic acid in rocks in which they did not show rutile during decay (*e.g.* Thürach, *op. cit.*).

That the granitic magma is titaniferous is often proved by the original sphene and rutile present. It seems as if after the separation of these the remainder of the titanic acid were absorbed in the biotite.

(*To be continued in our next Number.*)

REVIEWS.

I.—The School Manual of Geology. By J. Beete Jukes, M.A., F.R.S. Fifth Edition. Edited by A. J. Jukes-Browne, B.A., F.G.S. 8vo. 418 pages; with numerous Woodcuts. (Black, Edinburgh.)

THE late Professor Jukes's motive in preparing this small Manual was to aid young students to get clear notions in both technical and philosophical Geology, and to enable grown-up amateurs to realize "a fair general notion of the scope and nature of that Science." This end and aim has been well kept in mind in all subsequent Editions of the book, with conscientious care and creditable results of advanced knowledge in the many divisions of the subject-matter. As it now stands, the School Manual treats of—I. Geological Operations now in action: first, the earth is taken as a whole, with its external features and internal condition; (2) volcanoes are next considered, and earthquakes, and rise and fall of the ground; then (3) igneous rocks and their constituent minerals; (4) rocks mechanically formed, whether on the surface of the Earth by water, ice, and wind, or in the sea, not far from coasts; (5) rocks of organic origin, whether derived from the accumulation of plants, or of animals. Thus, (1) the destruction and reproduction of strata and other rocks; (2) geological time, as deduced from a consideration of the natural processes and operations, of which these are the results and evidences; (3) the balance of power in the constant action and reaction in the various physical agencies always at work on and in the Earth's crust, are brought clearly before the reader. II. Some of the facts observable in the Crust of the Earth, such as (1) strata or rock-beds, with their lamination and stratification; (2) rock-blocks, joints, also columnar and spheroidal structure; (3) concretions; (4) inclined and bent strata; (5) faults and lodes; (6) metamorphic rocks; (7) granitic rocks; (8) mountains, hills, and valleys; (9) uncon-

formity and overlap of strata: (10) the nature and occurrence of fossils; are briefly but distinctly noted, sometimes in detail. III. The history of the formation of the rock-groups found in the British Isles; (1) treating of geological history, time and nomenclature; (2) the Archæan or Eozoic period; (3) the Cambrian and Ordovician periods; (3–12) the Silurian, Devonian, Carboniferous, Permian or Dyassic, Triassic, Jurassic, Cretaceous, Older and Newer Tertiary, and Pleistocene systems and periods, are then taken in succession, with some of their most important fossils, in such a manner as to indicate the chief points to be remembered by the amateur, and to be further worked out by the real student.

Like the Author of this book, the Editor has had good technical experience, being engaged on the Geological Survey of Great Britain; he is also evidently a reading man, and conversant with old and new books; indeed we are glad to find him using the new (second) Edition of the Rev. O. Fisher's "Physics of the Earth's Crust," only a few months old. The aid which Mr. Jukes-Browne has received from Professor Bonney with regard to Petrology, especially Igneous and Metamorphic rocks, and from Mr. Whitaker about the Cretaceous and Tertiary formations, is gratefully acknowledged, and goes far to assure the student of the exact treatment these subjects have here received.

The names of good observers and writers are not unfrequently referred to in some parts of this "School Manual"; but few only are mentioned in connection with the palæontological chapters. If even the authorities for the species of those fossils which are figured had been given, the student would have had some clue to the palæozoology and palæophytology of the past, should he wish to carry out any investigations in Geology.

The illustrations throughout are mostly selected from those used in Professor Jukes's excellent "Students' Manual of Geology," which were nearly all original, and drawn for that book; and they still remain good and trustworthy. One very useful diagram (of "overthrust-faults") has been added at p. 161. Among the fossils, on the contrary, we should prefer to have seen the figures of "Pleistocene fossils" (given in a former edition of the "School Manual"), instead of the hideous and false portraiture of the Mammoth at page 396. The several parts of the borrowed fig. 102 require an explanation which they do not get; so also a part of fig. 80.

The plan of giving the derivation of the names of fossils, and indications of the prosodial "quantity" of their syllables, is very good, and much required now-a-days, when students of natural history are too often destitute of classical learning. The omission of some of these indications, as in *Pterinea*, *Hippopodium*, and *Goniopholis*; or misplacements, as in *Cardiŭm*; or mistakes, as in *Cuviĕri* and *Volŭta*, show the necessity of close reading for the press. Some of the explanations too would be the better for revision: thus, though of little consequence, Olĕnus was the son of Neptune and

not of Jupiter; *flabellifer* is "fan-bearer," not "fan-tail"; there is no basis for the word "plant" in the etymology of "*Stigmaria*," nor of "shell" in that of *Terebratula*, *Producta*, *Goniatites*, *Galerites*, etc.; *comptus* means "neat" rather than "ornamented"; and *grandis* "large" rather than "magnificent." *Labyrinthodon*, and other names with a similar ending, are regarded as masculine (as indeed is *Mastodon* in this book), and not neuter; "*Cardium*" is not really "a heart"; "*corangŭnum*" should be "snakes' (not snake's) heart," —*corangūnum*, snake-heart, is better; and *Ostrea* (not *Ostræa*) is correct. These and a few other such points should be attended to for the sake of illiterate beginners.

There is but little else to be found fault with:—perhaps, however, we should note the carelessness of expression at p. 41 (repeated from earlier editions), where the Esquimaux boat-poles, though they have been moved inland, still remain beneath the sea. The retention of "Plastic Clay" in place of "Woolwich and Reading Beds," as also in former editions, has evidently escaped the Editor's notice (p. 333). At page 362 the basalt of Antrim is referred to as of Miocene age, but on the previous page it is placed among the "Eocene Volcanic Rocks," being of the same age as those of Mull, which have Eocene plants interstratified with them. This discovery ought to have been credited to Mr. J. S. Gardner, as an important correction of a former notion about the existence of Miocene beds in the British Islands.

The chapters on the Palæozoic formations are much improved; but necessary succinctness has limited the subject very much. Still, Wales ought not to have had its chief Coal-field put into the South of England. The Ordovician and Cambrian are carefully distinguished from the Silurian proper, and from the Pre-Cambrian and Archæan rocks. The Cambrian *Hymenocaris*, however, ought not to be still handed down with three front spikes (p. 240), which Mr. Salter long ago did away with; and the organic standing of *Oldhamia*, having been doubted, cannot at present be dogmatically defined (p. 231).

Among the good points in this little book, we may notice that the rival theories of the formation of Coral Islands are very carefully placed before the student (pp. 97—110). We doubt, however, if Prof. Jukes would have so freely accepted Mr. Murray's views as the Editor seems to think.

The decided value and usefulness of this "School Manual" authorize us to offer the foregoing remarks on some shortcomings for the Editor's consideration,—being assured that the book is well suited to teacher and student in advancing the progress of liberal education, and therefore worthy of all the improvements that its limits will allow. Believing that the success which it has already enjoyed will continue and increase, as it well deserves, we cordially recommend this book to school-masters and their classes, as well as to students and amateurs.

II.—North American Geology and Palæontology for the Use of Amateurs, Students, and Scientists. By S. A. Miller. 8vo. pp. 664: 1194 figs. in text. (Cincinnati, Ohio, 1889.)

THIS is to all intents and purposes a third edition of the "American Palæozoic Fossils," which first appeared in 1877, and which, increased by a supplement, was re-issued in 1883. These editions however were without illustrations, and the later one comprised but half the number of pages which the present volume, weighty certainly in its mass, runs to.

The author begins his preface with the statement that "a general knowledge of Geology is probably of greater importance to the people of the United States than a like amount of information in any other department of natural science," a remark which may certainly be held capable of application to a yet wider section of the globe.

Turning to the work, however, it appears that "North American Geology" is compressed into 100 pages, including 16 on "definitions and laws of geology," and 10 on the subject of "nomenclature" of fossils, whilst the remainder of the work, if we except the glossary and index, is devoted to "North American Palæozoic Fossils."

This part is further subdivided. The "Vegetable Kingdom" forms a section by itself: the "Animal Kingdom" is portioned out into zoological subkingdoms, under each of which the genera are arranged alphabetically, and prefaced by general remarks on the group.

The alphabetical method in a work intended for students has its advantages; nevertheless, since the zoological arrangement of the subkingdoms necessitates the addition of an idea for the benefit of the tyro in palæontology, it is hard to see why the whole should not either have been carried out on the dictionary plan or systematically disposed.

The chapter on nomenclature practically popularizes the British Association rules, but we do not call to mind in that code any retrospective regulation to the effect that "a name should always be rejected when it outrages decency." It is true names were coined in early days of natural history which no right-minded person would even think of inventing now-a-days; but if they pass current to-day, it is assuredly not because their extraction is thought of; they are names and nothing more, and to seek to alter them now would be to needlessly imitate those maiden ladies of America who draped their table-legs and studiously avoided all mention of the naked eye.

Puns are abhorrent to the author, who decrees that "Latin puns on names, as faba after Mr. Bean, should be rejected in all cases as a poor joke." "Buffoonery," we are told, "has no place in science." And yet somehow or other we cannot quite disabuse our minds of the impression that the author himself is attempting to play off a big joke on the geological student.

How else are some of the following statements to be accounted for? "The Palæozoic Protozoa are included in two classes, viz. Rhizopodæ and Poriferæ." "The Poriferæ include the Sponges and are not to be regarded as any more highly organized than the

Rhizopodæ." Again, after strenuously upholding the law of priority (p. 92), he proceeds to remark à propos of *Orophocrinus* (p. 265), "The definition was very imperfect and was made in a foreign language, in a foreign country, and in a journal having no circulation in America where the fossil occurs," and proceeds to conclude that this name must give way to *Codonites*, Meek & Worthen, 1869!

The list of families given at the head of each section is sometimes remarkable, those into which he distributes the Palæozoic Sponges is especially so. Some of these families have not yet been described and are given with all their species marked "(in press)." The Beatricidæ (with the single type genus) and the Stromatoporidæ have long been removed from the Sponges, and *Palæacis*, here the sole genus of a family, is generally considered to be a Coral. The Pharetrones are calci-sponges, but not one of the four genera here referred to them is. In the class Crinoidea, the genus *Melocrinus* does not appear with the other genera under Melocrinidæ, but under Actinocrinidæ, whilst *Taxocrinus* appears under two families—Ichthyocrinidæ and Taxocrinidæ!

In the Gasteropoda the genus *Turbo* is illustrated by the type species *T. marmoratus*, and fully described, the paragraph concluding with the following gem: "Not an American Palæozoic genus. The species left here is, for want of material, to refer them to where they belong"!

Under "Lamellibranchiata" we learn that "Shells having a siphon are always gaping at the posterior or anterior side, or at both"! *Arca* is "unknown in the Palæozoic rocks," and *Cucullæa* "is not a Palæozoic genus." Under "Pisces" we find the synonyms *Mecolepis* and *Eurylepis* given as distinct genera, and the species put under the former all repeated under the latter.

The palæontological part of the work is extensively illustrated by figures drawn from every available source, and consequently of very unequal value, a few being as excellent as the majority are the reverse. They will probably prove more useful as "reminders" to the palæontologist than as aids to the identification on the part of the student.

In this edition, whilst the etymology of the generic names is given in the text, that of the specific is gathered into a glossary, endless repetition being thereby avoided. Here emendation is as necessary as in the rest of the volume. To find that 'adnatus' means 'adnate,' 'basalticus' is 'basaltic,' and that 'chrysalis' is 'chrysalis,' may be satisfactory to some minds, but can hardly be called explanatory. The translation of 'bipartitus' into 'two-parted' is not very happy, whilst the rendering of 'perspicator' by 'sharp-sighted' is hardly as correct as it should be. The inflections attributed to certain comparative adverbs as 'minus, a, um, less' are novelties that will interest the philologist without, however, instructing the youth to whom the little book is dedicated.

Notwithstanding all its faults, the book has considerable value as a work of reference to the literature of North American Palæozoic Palæontology, and in the hands of a moderately competent editor would become a priceless treasure to the working palæontologist.

III.—A Guide to the Exhibition Galleries of the Department of Geology and Palæontology of the British Museum (Natural History), Cromwell Road, London, S.W. Part I. Fossil Mammals and Birds. With 119 Illustration and 1 Plan; 103 pages, 8vo. Part II. Fossil Reptiles, Fishes, and Invertebrates. With 94 Illustrations and 1 Plan; 109 pages, 8vo. Price Sixpence each Part. Printed by Order of the Trustees, April, 1890.

THE Trustees and Officers of the British Museum have in many ways shown their earnest desire to render the collections under their care as useful as possible, both to students and the general public. The Natural-History branch of the Museum provides useful "Handbooks" and "Guides," besides more elaborate "Catalogues," and the Department of Geology and Palæontology is well furnished with such necessary means of instruction, suited both to save the time of the amateur who wishes to learn what the specimens in the Cases have to teach, and to direct the student at once to those parts of the Collection that will serve to increase his knowledge. A "Guide" to the Department was issued in 1881, and the four successive editions, each illustrated and enlarged, that have followed, have been well appreciated by the public, for 15,000 copies have been issued. Of late years many interesting and rare Fossils have been added to the Collection, and "Museum Catalogues" of Fossil Mammalia, Reptilia, Amphibia, Fishes, Crustacea, Cephalopoda, Blastoidea, Sponges, Foraminifera, and Coal-plants have more particularly been prepared technically and scientifically by various specialists. The new edition of the Guide-book has necessarily been augmented with notices of the chief types and varieties of the vertebrate animals mentioned in those Catalogues and elsewhere; and gives references to the subject-matter of such Catalogues and special works as elucidate the structure and characters of the Invertebrata. So much indeed has this hand-book increased that it is now published in two parts, each of which is larger than the former "Guide." Part I. contains 116 woodcuts and a frontispiece; Part II. has 94 woodcuts. In the "Guide" (especially in the first part), figures of recent specimens are placed near those of the fossils in several instances for comparison, and to enable the beginner to compare what is easily known with the more obscure and often imperfect remains of extinct forms.

If any fault can be found with regard to the number of illustrations, it is that in some cases they appear to be excessive. Thus, in treating of the order Chelonia, in pt. ii. pp. 38–41, we find a number of illustrations which do not seem necessary to explain the text, and, indeed, are, for the most part, not even mentioned therein. The greater number of the excellent illustrations with which the work is adorned have been reproduced from the recently-published 'Catalogues' of Fossil Mammalia, Reptilia, and Amphibia; but a few, such as the skull of *Samotherium* and the skeleton of *Lariosaurus*, have been executed specially for the present work. We may mention that the fourth part of the 'Catalogue of Fossil Reptilia

and Amphibia' was still in the press at the time of publication of the 'Guide,' but numerous figures of Reptiles and Labyrinthodonts have been taken therefrom, and the author has had the opportunity of seeing the proof-sheets. This will account for the appearance in part ii. pp. 65–66, of the new name *Metoposaurus*, which has been proposed in the 'Catalogue' to replace the preoccupied one of *Metopias*.

In the great majority of instances some explanation is given of the structure and affinities of the genera mentioned; but in some cases we venture to think such explanations are somewhat too technical to suit the popular taste; while in others we meet with lists of names without any distinct clue as to what kind of creatures they really represent.

The first part is devoted to the consideration of the Mammals and Birds; the former coming in for a very full treatment, both as regards letterpress and illustrations. We are glad to see a very considerable advance in the systematic treatment of this group, the author having for the most part brought his descriptions fully abreast of the modern views. We may notice, however, that the introduction of the discarded term Quadrumana on page 4 appears unnecessary, and liable to lead to confusion. And on the same page, we think, it would have been advisable to point out which genera of Monkeys and Apes are still living and which are extinct, and also to have arranged them according to their families. Thus we find *Anthropopithecus* (Chimpanzee) separated from its extinct ally *Dryopithecus*; while the extinct *Mesopithecus* should have occupied, as its name implies, the middle position between the living *Macacus* and *Semnopithecus*.

A large series of figures illustrates very fully the gradual advance in the specialization of the molar teeth of the Proboscideans; a group of which the Museum contains the finest collection extant. In speaking of the *Macrauchenia*, at p. 30, as a specialized Ungulate, we presume the author rather intended to use the term "generalized." Again, in treating of the Horses, at p. 39, the author appears to have become involved in some confusion between *Equidæ* and *Lophiodontidæ*, since he mentions the genus *Eohippus* among the former family, whereas its true position is in the latter. We may mention in passing that the recent observations of Messrs. Scott and Osborn have shown that *Eohippus* is really identical with *Hyracotherium* (p. 38); *Orohippus* being the same as *Pachynolophus*. The new views as to the probable Metatherian affinity of the Mesozoic Multituberculata are adopted. Why the author will persist in using the name *Castor europæus*, Owen (p. 9), in place of *C. fiber*, Linn., is a point on which we should be glad to receive further information.

In the Birds the classification of the extinct and recent types proposed by Prof. A. Newton has been followed; the presence or absence of teeth not being regarded as features of ordinal importance.

The second part is devoted to the Reptiles (including Amphibians), Fishes, and Invertebrates. Since, however, a special guide to the Fossil Fishes has been already published, mention is only made of

the chief groups into which the class is divided. The same brevity is noticeable in regard to the Invertebrates; and there is also a short notice of the Fossil Plants. The concluding sections of this part refer to the very interesting historical and stratigraphical collections exhibited in the Department. The fine series of fossil footprints is also mentioned; and in this connection we notice that the student is liable to be misled by the unfortunate slip of the name *Cheirotherium* occurring in the text, while the explanatory illustration bears the legend *Chirosaurus*.

The author in treating of the Reptiles and Amphibians follows in the main the classification adopted in the Museum Catalogues. In retaining the name *Ornithopsis* (p. 10) in place of the earlier *Hoplosaurus* (p. 12) the author sets, however, a false precedent, since if we do not hold by the rule of priority there is not the least reason why *Ornithopsis* itself should be held preferable to *Eucamerotus*; indeed the reverse is the case, since the remains on the evidence of which the name *Ornithopsis* was proposed were never figured by their describer, while those described as *Eucamerotus* were fully illustrated.

The magnificent series of Ichthyosaurian and Pliosaurian remains preserved in the Museum meets with full recognition; the illustrations indicating the chief structural peculiarities of these groups. The description of the anatomical structure at p. 33 is, however, one of those instances to which we have already alluded where the technicalities seem to be too great. Thus we very much doubt whether the ordinary reader will have the slightest idea what an 'obturator notch,' or a 'precoracoid' means. If indeed such terms are introduced at all in a work of this nature, they should be fully explained and illustrated by diagrams.

In raising the peculiar Placodonts to the rank of an order, the author departs from the usual view without any sufficient justification. In the diagnosis of the order Anomodontia we again deplore the extreme technicality of the terms, and venture to affirm that these will be utterly unintelligible to the ordinary visitor, while the student will of course seek elsewhere for his information. If such technicalities are admissible at all, it should surely have been clearly explained by the aid of a figure that the precoracoid of many Anomodonts differs from that of all other Reptiles in being an absolutely distinct bone. The features in which these Reptiles approximate to the Monotreme Mammals might also have been advantageously indicated, as they are the most interesting points in connection with the group. A protest must also be entered against the decisive reference of the Karoo System of the Cape to the Trias, in face of the arguments brought against this view by Mr. W. T. Blanford and others. Some of the figures illustrating the osteology of the Anomodonts are all that can be desired.

Notices of historical and type collections, and of stratigraphical and other special groups of specimens, at pages 92–100, comprise remarks on Sir Hans Sloane's, Brander's, William Smith's, Sowerby's, Gilbertson's, Searles Wood's, F. E. Edwards', and Davidson's collec-

tions; besides the specimens of König's "Icones," bored rocks, tracks, trails, footprints, cores from borings, etc.

The descriptive paragraphs not only give details as to the localities and peculiarities of the fossils, but are frequently rich with philosophic thought on the relationship and probable descent of the animals themselves.

Each Part contains a plan and explanation of the saloons or galleries and cases of those fossils of which it treats, also a good index; and is complete in itself.

In thus endeavouring to popularize an abstruse but exceedingly fascinating branch of science, and in giving to the public such a full shilling's worth, the author (Dr. H. Woodward) and the Trustees of the British Museum are to be highly congratulated; and we trust that the public will show its appreciation of the work by rapidly buying up the present edition, and thus enabling the author to issue another edition incorporating some of the slight improvements we have ventured to suggest.

A list of the Museum Catalogues relating to Zoology and Palæontology, and of Guide-books for the Zoological, Geological, and Mineralogical Departments, is added.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 16, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On the disturbed Rocks of North-western Germany." By Prof. A. von Könen, For.Corr.G.S. (Communicated by Sir Warington W. Smyth, F.R.S., F.G.S.)

After referring to the disturbances of Palæozoic times, the author commented upon the Miocene dislocations of the Harz, Rhineland, Westphalia, and Nassau, which have a N.W.–S.E. strike, varying to N.–S. or E.–W., and which are similar to post-Glacial dislocations.

He briefly discussed the origin of these dislocations, and noticed their peculiarities, and proceeded to consider the relationship of the intruded basalts to the disturbances, supposing that during the process of faulting, the earth's crust was pressed downward along synclinal lines, and that the basaltic magma escaped upwards through the inverted funnel-shaped synclinal fissure.

Comparison was made between these Tertiary basalts and the products of modern volcanic eruptions, and it does not appear to the author to be unlikely that the cause of the outflow of many of the lavas in the latter was similar to that which produced the extension of the Tertiary basaltic rocks.

2 "On the Origin of the Basins of the Great Lakes of America." By. Prof. J. W. Spencer, M.A., Ph.D., F.G.S., State Geologist of Georgia.

From the study of the hydrography of the American lakes, from

the discovery of buried channels revealed by borings, from the inspection of the glaciation of the lake-region, the consideration of the late high continental elevation, and the investigation of the deformation of old water-levels, as recorded in the high-level beaches, the explanation of the origin of the basins of the great lakes becomes possible.

The original Erie valley drained into the extreme western end of Lake Ontario—the Niagara river being modern—by a channel now partly buried beneath drift. Lake Huron, by way of Georgia Bay, was a valley continuous with that of Lake Ontario; but between these two bodies of water, for a distance of about 95 miles, it is now buried beneath hundreds of feet of drift. The old channel of this buried valley entered the Ontario basin about twenty miles east of Toronto. The northern part of Lake Michigan basin was drained into the Huron basin, as at present; whilst the southern basin of the lake emptied by a now deeply drift-filled channel into the south-western part of Huron. The buried fragments of a great ancient valley and river, and its tributaries, are connected with submerged channels in Lake Huron and Lake Ontario, thus forming the course of the ancient St. Lawrence (Laurentian) river, with a great tributary from the Erie basin and another across the southern part of the State of Michigan. This valley is of high antiquity, and was formed during times of high continental elevation, culminating not long before the Pleistocene period. The glaciation of the region is nowhere parallel with the escarpments, forming the sides of, or crossing the lakes or less prominent features. During the Pleistocene period, and especially at the close of the episode of the Upper Till, the continent was greatly depressed, and extensive beaches and shore-lines were made, which are now preserved at high elevations. With the re-elevation of the continent these old water levels have been deformed, owing to their unequal elevations. This deformation is sufficient to account for the rocky barriers at the outlets of the lakes. Some of the lakes have been formed, in part, by drift obstructing the old valley. The origin of the basins of the Great Lakes may be stated as the valley (of erosion) of the ancient St. Lawrence River and its tributaries, obstructed during, and particularly at the close of the Pleistocene period, by terrestrial movements, warping the earth's crust into barriers, thus producing lake-basins, some of which had just been formed in part by drift deposited in the ancient valley.

3. "On Ornithosaurian Remains from the Oxford Clay of Northampton." By R. Lydekker, Esq., B.A., F.G.S.

Seven vertebræ, portions of the ilia and ischia, one femur, and the distal portion of that of the opposite side, part of a bone, probably from the shaft of the tibia, and two undetermined fragments, all associated, indicate the existence in England during the Oxford-clay period of the species of *Rhamphorhynchus* provisionally referred to *R. Jessoni*, though not definitely distinguished from *R. Gemmingi*.

Amongst the noticeable features of the specimens are the presence of a distinct rib-facet at the lateral border of the inferior surface

of the centrum of the cervical vertebræ, proving the existence of cervical ribs, and the character of the neural spine of a dorsal vertebra which strikingly recalls that of a bird.

4. "Notes on a 'Wash-out' found in the Pleasley and Teversall Collieries, Derbyshire and Nottinghamshire." By J. C. B. Hendy, Esq. Communicated by Dr. W. T. Blanford, F.R.S., F.G.S.

Sections were given of the "Wash" showing the thickening of the coal as it approaches the same, and the splitting of the "Wash" itself into two branches. Various measurements were noted, and certain disturbances recorded. In every section examined, the sides of the "Wash" are more or less slickensided, and in some few cases the coal is distorted next to the "Wash"; but the author is of opinion that these are due to lateral pressure and movement subsequent to the denudation of the coal and deposition of the sandstone, and he remarks on the difficulty of reconciling the regularity of the underclay with the theory of the formation of "Washes" by disturbance.

He considers that they are due, in Durham and elsewhere, to currents flowing at a high rate of speed in one direction, carrying away the denuded material, and, as in the case of the Derbyshire "Wash," to a series of inundations, each inrush denuding a certain amount, and on subsiding, redepositing part of the material at a higher level, while the remainder was carried away in suspension.

In conclusion, notice was taken of "washes" occurring in other localities.

II.—April 30, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "On certain Physical Peculiarities exhibited by the so-called 'Raised Beaches' of Hope's Nose and the Thatcher Rock, Devon." By D. Pidgeon, Esq., F.G.S.

The author described the peculiarities of these so-called beaches, including the absence of stratification, the presence of splinters of rock like that of the overlying limestone cliffs, the scarcity of rounded pebbles, and the great abundance of sharply fractured shells associated with unbroken rock-dwelling shells.

He enumerated the fossils collected from these deposits by Mr. A. R. Hunt, which include *Trophon truncatus* and *Pleurotoma turricula*, and calling attention to the observations of Messrs. Feilden and De Rance, and of Dr. Moss upon the ice-foot of Arctic regions, and the accumulation of material in the trenches found therein, concluded that the deposits under consideration were formed at a time when a small bay existed between Hope's Nose and the Thatcher Rock, which has since been destroyed by denudation of the intervening sandstone, in which bay an ice-foot once existed; and further, that the two deposits from the surviving relics of the mingled mass of chips, shells, shell-fragments, Crustacea, etc., which must have filled the trench in the ice-foot demanded in such a position. This would place the time of formation of the deposits at the close of the Glacial period.

2. "The Devonian Rocks of South Devon." By W. A. E. Ussher, Esq., F.G.S., of H.M. Geological Survey.

This paper is the result of work done in continuation of the labours of the late Mr. Champernowne, and refers particularly to the area north of the Dart and east of Dartmoor.

Owing to the complicated stratigraphy of the region, we have to fall back upon such information as can be procured of the general types of Upper, Middle, and Lower Devonian faunas; for though the lithological constituents of these three divisions are broadly distinguishable, there are no definite lithological boundaries between them.

The Lower Devonian is mainly distinguished by the occurrence of sandstone and grit, but the upper beds are shales passing into the Middle Devonian slates.

The Middle Devonian consists of limestones, and shaly limestones upon slates, the latter representing the Calceolen-Schiefer, and containing *Spirifer speciosus*. *Stringocephalus* is found here and there in the Middle Devonian Limestones. The upper part of the Middle Devonian Limestones (with Lummaton fauna) passes into the *cuboides*-beds of the Upper Devonian. The Upper Devonian contains thin-bedded limestones, often concretionary, with chocolate-red and pale greenish slates and mudstones. These beds correspond to the Goniatiten-Schichten, Kramenzelstein and Knollenkalk of Germany, and to the Cypridinen-Schiefer.

In the Upper and Middle Devonian rocks we find a local prevalence of schalstein ard tuffs, breaking up the limestones. The slate and sandstone type of Upper Devonian in North Devon appears to give place southward to a purely slate type, possibly accompanied by overlap of the Culm-measures. The author groups the South Devon rocks under the following heads:—

Upper ...	1.	Cypridinen-Schiefer.
	2.	Goniatite-limestones and slates.
	3.	Massive Limestones.
Middle ...	4.	Ashprington Volcanic Series.
	5.	Middle Devonian Limestones.
	6.	Eifelian slates and shaly limestone.
Lower ...	7.	Slates and sandstones, generally red.
	8.	Slates with hard grits.

After discussing the relationship of the Lincombe and Warberry beds and the New Cut Homalonotus-beds, the author notes the discovery of *Pleurodictyum* by Mr. Whidborne in the railway-cutting at Saltern Cove. He proves the Lower Devonian age of the Cockington beds and their correlation with the Torquay Lower Devonian by the discovery of fossils. He considers it probable, though not certain, that the main mass of Meadfoot beds is below the Lincombe, Warberry, and Cockington sandstones.

The distribution of the Middle Devonian Limestones is described. *Stringocephalus* is found in limestones containing *Rhynchonella cuboides*. The upper parts of the limestone-masses (East Ogwell, Kingskerswell, Barton, Ilsham, etc.) may be Upper Devonian. The massive limestones may terminate abruptly or pass laterally into

shales, and the whole mass of the limestones seems to be replaced by slates between the Yealmpton and Totnes areas.

The commencement of the phase of volcanic activity which caused the accumulation of the Ashprington series is shown to coincide with the latest stage of Eifelian deposition, and the Ashprington series may represent continuous or intermittent vulcanicity up to a late stage in the Upper Devonian. North of Stoke Gabriel a mass of limestone seems to have been formed contemporaneously with the volcanic material on the immediate borders of which it occurs. Elsewhere the limestones are interrupted by local influxes of volcanic material. The occurrence of other local developments of Middle and Upper Devonian volcanic rocks is described.

The relationship of the Middle and Upper Devonian deposits varies. In some cases Upper Devonian shales may have been deposited against Middle Devonian limestones; in others there is a continuous development of limestone, the Middle Devonian limestones being succeeded by *Cuboides*-beds, *Goniatite*-limestones, and Knollenkalk. The local variations of these are described, and fossil-lists given. The Knollenkalk is shown to pass under *Entomis*-bearing beds ("Cypridinen-Schiefer"), which are described, though a detailed account of their relationship to the Culm-measures is reserved for a future occasion.

III.—May 14, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "The so-called Upper-Lias Clay of Down Cliffs." By S. S. Buckman, Esq., F.G.S.

The blue clay of Down Cliff, Dorset, which has been referred to the Upper Lias, has yielded Ammonites of the genus *Dumortieria* to the author, notably *D. radians*. This blue clay is *below* the Yeovil Sands; but the position of *D. radians* in the Cotteswolds is in the limestone *above* the Cotteswold Sands, which has been placed in the Inferior-Oolite series.

The author, by combining the Down-Cliffs and Chideock-Hill sections, obtains a sequence of beds from the Middle Lias to the top beds of the Inferior Oolite, including the zones of *spinatum*, *commune* and *falciferum*, *jurense*, *opalinum*, *Murchisonæ*, *concavum*, and *Parkinsoni*.

The genus *Dumortieria* binds the *opalinum*- and *jurense*-zones together; while at Symondsbury Hill the author has found *Ludwigia Murchisonæ* and *Lioceras opalinum* in the same bed, which renders it difficult to draw a line of demarcation between Lias and Oolite at the top of the *opalinum*-zone.

The facts adduced in the paper furnish additional evidence of the unreliability of a grouping which depends upon lithological appearances, and it was because no satisfactory line could be drawn between Lias and Oolite that the author, in a previous paper, supported the continental plan of grouping Upper Lias and part of the Inferior

Oolite under the term Toarcian upon palæontological grounds. In the present paper he furnishes further statements in support of this view.

2. "On some new Mammals from the Red and Norwich Crags." By E. T. Newton, Esq., F.G.S.

This paper contains descriptions of mammalian remains from the English Pliocene belonging to eight species, nearly all being new to the Crags, and four of them new to science. A remarkable low-crowned, but broad, lower carnassial tooth from the Norwich Crag of Bramerton is referred to the genus *Lutra*, and named specifically *L. Reevei*. All the other specimens noticed below are from the nodule-bed at the base of the Suffolk Red Crag, and the first four of them are in the possession of Mr. E. C. Moor, of Great Bealings. A right ramus of a lutrine lower jaw, differing from the common Otter in having the hinder fangs of the premolars much larger than the front ones, and agreeing in this particular with the *Lutra dubia* of De Blainville, is referred to the latter species. A humerus of a Seal, most nearly resembling that of *Phoca vitulina*, but of smaller size and more slender proportions, is called *Phoca Moori*. Another Seal's humerus, having a peculiarly triangular shaft, is thought to belong to the *Phocanella minor* of Van Beneden. A maxilla with three teeth, evidently belonging to the genus *Trogontherium*, but of smaller size than the *Trogontherium Cuvieri*, is believed to represent another species, and is named *T. minor*. The ziphioid rostrum in the Ipswich Museum, which received from the Rev. H. Canham the MS. name of *Mesoplodon Floweri*, is for the first time described; and another rostrum in the Museum of Practical Geology, characterized by being very short and with a deep boat-like anterior extremity, is named *Mesoplodon scaphoides*. The peculiar species *Ailurus anglicus*, hitherto known only by a piece of a lower jaw with a carnassial tooth, is now further illustrated by a fine upper molar recently presented to the Museum of Practical Geology.

3. "On Burrows and Tracks of Invertebrate Animals in Palæozoic Rocks, and other Markings." By Sir J. William Dawson, LL.D., F.R.S., F.G.S.

This paper, which is illustrated by photographs and drawings, indicates some new facts in connection with the markings produced by the burrows and tracks of animals and by other causes. *Rusichnites* and *Cruziana* are regarded, like *Climactichnites* and *Protichnites*, as representing probable burrows of Crustaceans and Chætopod worms. *Scolithus canadensis* is shown to be a cylindrical burrow, with accumulations of earthy castings at its mouth. The relation of these burrows to the forms knows as *Scotolithus*, *Asterophycus*, *Monocraterion*, and *Astropolithon* is pointed out.

Under the new generic name of *Sabellarites* the author describes certain tubes, composed of shelly and other fragments cemented by organic matter, found in the Trenton Black-river Limestone. They resemble the burrows or tubes formerly described by the author from the Hastings and Quebec Groups, and appear to be the tubes

of worms allied to the recent *Sabellariæ*; but they are liable to be mistaken for Algæ of the genera *Palæophycus* and *Buthotrephis*.

Some large cylindrical bodies from the Potsdam Sandstone are described as having been supposed to be trunks of trees; but the author regards them as probably concretions formed around slender stems, like some now forming in the alluvial mud of the St. Lawrence.

Some curious combinations of worm-tracks with ripple-marks and shrinkage-tracks are described; as also branching or radiating worm-trails, which present some resemblance to branching Fucoids. Finally the author described the formation of rill-marks on the mud-banks of the tidal estuaries of the Bay of Fundy, and indicates their identity with some impressions in slabs of rock which have been described as Fucoids under several generic names.

4. "Contact-alteration at New Galloway." By Miss M. I. Gardiner. Communicated by J. J. H. Teall, Esq., M.A., F.G.S.

A description is given of an alternating series of grits and shales occurring at the eastern end of the northern edge of the Cairnsmore of Fleet granite-mass. The rocks here are generally more altered than around other parts of the granite margin. The author describes a transverse section about half a mile from the granite, and traces the changes which occur in the rocks when passing towards the granite. She notices (1) the extreme variation in the amount of alteration in different places, but at the same distance from the granite; (2) the entire recrystallization, in one locality, of the shales for about 2 feet and of the grits for about 100 yards from the granite margin; that material seems to have travelled through the rock, so that the most altered grit largely consists of crystals, here of one mineral, there of another, as though material had been conveyed from one part of the rock to another to form small nests; (4) the apparent order of succession of the minerals, garnets rarely containing anything but colouring-matter and quartz, chiastolite containing garnets, and bands of mica sweeping round both; (5) evidence which appears to the author to indicate dynamic metamorphism, as furnished by the sigmoidal folding of knots in the shales and by the appearance of phenomena suggesting thrust-planes.

The author considers, however, that the main metamorphism is due to the intrusion of the granite, and that the variation in the amount of alteration at the same distances, the mode of alteration of the grits, and the transference of material might be accounted for by the passage of highly heated water. Other evidence points to the changes having been brought about slowly.

Among the minerals produced in the contact-zone are secondary quartz, felspar, brown and white micas, chiastolite, sillimanite, and garnet, their modes of occurrence being described in detail, in rocks of various degrees of alteration up to those in an abnormally high state of alteration near the granite, which resemble rocks of doubtful origin in other localities.

CORRESPONDENCE.

PROCEEDINGS OF THE COTTESWOLD NATURALISTS' FIELD CLUB.

SIR,—Over the familiar initials H. B. W. appears a notice of the above Club, vol. ix. pt. iv. (GEOL. MAG. Dec. III. Vol. VII. p. 88). A large part of this notice is, I am sorry to see, occupied in a criticism upon my system of nomenclature.

Mr. H. B. W. is, really, not complimentary to the members of the Cotteswold Field Club. He leads us to imagine that they are unable to cope with anything which has not been thoroughly approved of, and digested by, the text-books, not as if one were writing for scientific men, but as if one were addressing the raw students of a newly-formed Natural History class.

Another idea which H. B. W. puts forth is, that there shall be really two systems of nomenclature—one for the use of specialists among themselves, and the other for the consumption of stratigraphists and general readers. Already there are complaints that one system is enough to remember; now we are to have two, to be varied according to the supposed capacities of the audience! What would be the result? The stratigraphist would soon be unable to comprehend the palæontologist, instead of being gradually educated up to him, as at present.

I can, however, throw out one suggestion whereby all authors can help the general reader, namely, by differentiating, in lists of fossils, Brachiopoda, Cephalopoda, etc., by the use of those terms as headings; or, sometimes, by indicating smaller divisions, such as Ammonites, Goniatites, Nautili. The general reader would know then, at any rate within some limits, to what an unknown generic name applied. This suggestion, however, is quite as necessary to those using old, as to those employing new, generic names.

S. S. BUCKMAN.

OBITUARY.

JOHN EDWARD TENISON WOODS.

ONE of the pioneers of Australian geology has passed away by the death of the late Vicar-general of Adelaide. Mr. Woods first settled in Australia about 1857, and in that year issued his paper, "Observations on some Metamorphic Rocks in S. Australia." This was followed by others, "Geological Observations on S. Australia," in 1862, and by his "Tertiary Fossils of South Australia," in 1865. His greatest work, "A History of the Discovery and Exploration of Australia," was published in 1862, and besides being a most useful compilation, it contained some valuable additions to Australian palæontology. In 1867, in a paper on "The Glacial Deposits in Australia," he made the first attempt to prove the past existence of an Ice age in that Continent. In later years Mr. Woods rather abandoned geology, but he did much good work on the recent mollusca of Australia and Tasmania. He was also interested and wrote occasionally on meteorology. In 1880 he served as President of the Linnean Society of New South Wales. He died at Sydney on the 9th of October, 1889.